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Gestational Diabetes, Infant Feeding Practices, and Early Indicators of Obesity Risk in a Sample of Mother-Infant Dyads in the U.S.

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GESTATIONAL DIABETES, INFANT FEEDING PRACTICES, AND EARLY INDICATORS OF OBESITY RISK IN A SAMPLE OF MOTHER-INFANT DYADS IN THE U.S.

A Dissertation Presented

by

KIMBERLY N. DOUGHTY

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ABSTRACT

GESTATIONAL DIABETES, INFANT FEEDING PRACTICES, AND EARLY INDICATORS OF OBESITY RISK IN A SAMPLE OF MOTHER-INFANT DYADS IN THE U.S.

SEPTEMBER 2015

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Research suggests that the trajectory to obesity and its associated metabolic disorders begins very early in life. Prenatal exposure to maternal gestational diabetes mellitus (GDM) is associated with increased risk, while breastfeeding is associated with reduced risk. Breastfeeding may influence obesity risk in part by preventing rapid postnatal weight gain. There is some evidence that mothers with gestational diabetes do not breastfeed as often or as intensely as healthy mothers, potentially exacerbating the risk to their infants. The purpose of this research was to undertake three distinct investigations relating to selected maternal factors and infant feeding practices that are associated with obesity in children: 1) to investigate the associations between breastfeeding intensity, exclusive breastfeeding duration, and risk of rapid weight gain in infancy; 2) to compare the breastfeeding intentions and practices of mothers with gestational diabetes to those of healthy mothers; and 3) to estimate the associations between gestational diabetes and breastfeeding-related knowledge, attitudes, and beliefs during pregnancy, and breastfeeding-related experiences in the neonatal period. All three

investigations were secondary analyses of the U.S. Infant Feeding Practices Study II. Multivariate logistic regression was used to estimate associations between all predictor and outcome variables, adjusting for relevant covariates.

In the first study, which included 1,225 mother-infant pairs, we found that compared to 100% breast milk feeds, likelihood of rapid weight gain was increased two-to-three-fold for infants who were not breastfed or were fed a mixture of breast milk and nonhuman milk. Exclusive breastfeeding (EBF) was not independently associated with rapid weight gain when adjusting for breastfeeding intensity. The second study included a prenatal sample of 212 women with GDM and 3,032 women with healthy pregnancies. Of these, complete postpartum data were available for 133 women with GDM and 1,918 healthy women. GDM was associated with a 46% reduced odds of ever EBF. Intention to breastfeed was similar in both groups. There was a suggestion of reduced intention to EBF among GDM women, but this was not significant. Infants of GDM mothers were 78% more likely to receive formula in the hospital, compared with infants of nondiabetic (NDM) mothers. However, there were no differences in duration of any or exclusive breastfeeding among GDM and NDM women who ever breastfed or ever exclusively breastfed, respectively. The third study included 2,815 NDM and 195 GDM women in the prenatal analyses and 1,626 NDM and 107 GDM women in postnatal analyses. During pregnancy, GDM women were nearly 40% less likely to report breastfeeding as optimal feeding and 74-78% more likely to indicate formula or mixed feeding as the preferred feeding by the infant's father. GDM women were nearly three times more likely than NDM women to indicate that their obstetrician or other physician preferred formula use, and were 30% less likely to report being comfortable breastfeeding in front of their

women friends. There were no differences between groups in knowledge of breastfeeding benefits or recommendations. Following delivery, infants born to women with GDM were 45% less likely to room-in with their mother. Women with GDM were 66% more likely to indicate that their infants had problems with sucking and twice as likely to say the infant showed no interest in breastfeeding. However, GDM women were 77% less likely to report “any other problem” with breastfeeding.

Together, the results of these studies suggest that high-intensity breastfeeding for the first 6 months of life may be necessary to prevent rapid weight gain in infancy, and that women with GDM may especially need extra support and encouragement during and after pregnancy to achieve optimal breastfeeding outcomes.

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CHAPTER 1

INTRODUCTION

It is now widely acknowledged that breastfeeding is the optimal feeding method for human infants.[1-3] The protective effects of breastfeeding are abundantly clear in developing countries, where it has been estimated that 1.45 million deaths among infants and children under age 3 are attributable to suboptimal breastfeeding each year.[4] In industrialized nations, the degree of risk posed by formula feeding may be less extreme, but there is nevertheless strong evidence for a protective effect of breastfeeding on a wide range of health outcomes for both mothers and infants.[5] For example, breastfed infants experience lower rates of gastrointestinal and respiratory illness.[5] There is also moderate evidence for long-term beneficial effects of breastfeeding on childhood obesity, and risk of developing type 1 and type 2 diabetes. Women who breastfeed may also experience lower risks of breast and ovarian cancers, type 2 diabetes, and postpartum depression.[5]

The potential protective association between breastfeeding and childhood obesity is of particular importance in the U.S., where childhood obesity rates have reached unprecedented proportions.[6] Infants who gain weight rapidly during the first one or two years of life are at significantly greater risk of becoming overweight later in childhood or adulthood.[7] They may also experience greater rates of cardiometabolic disturbances.[8] Breastfed infants follow a slower growth trajectory than their formula-fed counterparts,[9] and many studies have linked some measure of breastfeeding with lower risk of excess weight or rapid weight gain in infants.[10-16] There are, however, several limitations common to many of these previous studies. For example, most have involved cohorts outside the U.S. and, therefore, may not be generalizable to the American population and most previous studies have not employed early, frequent, and rigorous

assessment of infant feeding practices. Two studies were carried out in the U.S., but neither investigated risk for rapid weight gain as an outcome.[15,16] Additionally, both used the Centers for Disease Control and Prevention (CDC) growth charts to determine weight-for-age z-score. It is currently recommended that the World Health Organization growth charts be used to assess weight in infants and toddlers under the age of 2 years.[17]

Women with gestational diabetes, who have 4-11 times the risk of developing type 2 diabetes compared with women with healthy pregnancies,[18] may especially benefit from breastfeeding.[19] Their infants, who are at increased risk of obesity and glucose intolerance[20-23] may also experience reductions in obesity and diabetes risk if they are breastfed.[24-26] In one study, Studies have reported approximately 45-75% lower risk of obesity among breastfed vs. bottle-fed offspring of GDM mothers.[24,26] Long breastfeeding duration (>12 months)[26] or exclusive breastfeeding for at least 2 months[25] are associated with similar reductions in type 2 diabetes risk all children. However, few studies have investigated the breastfeeding intentions and practices of women with gestational diabetes, and those that have suggested that women with gestational diabetes mellitus (GDM) are less likely to breastfeed than their counterparts.[27]

It is not clear why women with GDM appear to have less favorable breastfeeding outcomes compared with nondiabetic mothers. Delayed onset of lactation (DOL) [28,29] is more common among women with any form of diabetes during pregnancy, but other problems with breastfeeding are not well-documented. A range of psychosocial factors likely contribute to breastfeeding intentions and practices.[30-33] Maternal attitudes toward the relative benefits and drawbacks of breastmilk vs. formula and breastfeeding in public are associated with increased breastfeeding duration.[30] Comfort breastfeeding in front of friends or in public;[32] knowledge, attitudes, and beliefs about breastfeeding;[32]; and perceptions of other's opinions about infant

feeding[33] have all been associated with intention to exclusively breastfeed. Although a few studies have examined breastfeeding behaviors in women with GDM, we are not aware of any that have investigated the psychosocial factors and early postpartum experiences that might contribute to reduced breastfeeding in this population.

CHAPTER 2

INFANT FEEDING OVERVIEW

2.1 Breastfeeding Recommendations and Definitions

Human breast milk is widely recognized in the medical and public health communities as the optimal food for infants. It is the position of both the World Health Organization (WHO)[3], the American Academy of Pediatrics (AAP),[2] and the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN)[34] that infants should be exclusively breastfed for 6 months, with continued breastfeeding when complementary foods are added for at least one year. Breastfeeding is of particular importance in developing countries, where access to nutritious food and safe water may be limited. It has been estimated that 1.3 million early childhood deaths in high-mortality countries could be prevented annually with optimal breastfeeding.[35] However, there are substantial benefits of breastfeeding for mothers and infants in developed countries as well.[36] These benefits are discussed in detail below, under *Breastfeeding and Health Benefits*. To promote exclusive breastfeeding, the AAP has outlined recommendations for health care practice,[2] which are summarized in Table 1.1.

The WHO definition of exclusive breastfeeding requires that the infant receive only breast milk, with the exception of drops or syrups used to deliver vitamins, minerals, or medicine.[37] Criteria for predominant breastfeeding allow for the use of water, water-based drinks, fruit juice, and oral rehydration salts, but no other foods or non-human milks. The term "full breastfeeding" is used to refer to both exclusive and predominant breastfeeding.[37]

Table 1.1. AAP Recommendations for Promoting Breastfeeding in Healthy, Term Infants

1. Health care providers should recommend breastfeeding whenever it is not contraindicated
    a. Expressed human milk is preferred when direct breastfeeding is not possible
2. Policies should encourage breastfeeding
    a. Both parents should receive prenatal and postnatal education
    b. Interventions for mother or infant that may interfere with breastfeeding should be avoided
3. Healthy infants should receive skin-to-skin contact immediately after birth whenever possible
4. Supplements of formula or other fluids should not be given unless medically indicated
5. Pacifier use should be avoided until breastfeeding is well-established
6. Eight to twelve feedings in each 24-hour period should be encouraged
7. Breastfeeding should be evaluated by trained clinicians at least twice daily during the hospital stay
8. Pediatric visits to assess weight and identify other problems are recommended at 3-5 days of age and 2-3 weeks of age
9. The benefits of exclusive breastfeeding for the first 6 months of age should be well understood by both parents and pediatric care providers
10. Breastfed infants should receive a vitamin K injection at birth and oral vitamin D drops (200 IU) daily; supplemental fluoride is not advised during the first 6 months of life
11. Infants should sleep near their mothers
12. When breastfeeding is temporarily impossible for any reason, the expression of milk with breast pumps and feeding of expressed milk should be encouraged

Adapted from Section on Breastfeeding. Breastfeeding and the use of human milk. Pediatrics. 2012;129(3):e827-41

2.2 Breastfeeding Practices in the United States

Data from the U.S. National Immunization Survey indicate that nearly three quarters of all infants born in 2008 were breastfed for some period of time.[38] Less than half (44.4%) of infants were still breastfed at 6 months, and just 23.4% were breastfed at 12 months of age. These rates fall short of the Healthy People 2010 targets of 75% in the early postpartum period, 50% at 6 months, and 25% at 1 year.[39] However, breastfeeding rates have improved somewhat in the U.S. in recent years. From 2000 to 2008, the proportion of all infants ever breastfed (+4.2%), breastfed at 6 months (+9.9%), and at 12 months (+7.4%) increased significantly.[38] Racial disparities in breastfeeding initiation and duration are still evident, but appear to have narrowed between 2000 and 2008.[38] Among Blacks, breastfeeding initiation increased from 47.4% to 58.9%.[38] The proportions of Black infants who were breastfed at 6 months and 12 months increased from 16.9% to 30.1% and from 6.3% to 12.5%, respectively.[38] Significant increases were also observed for Hispanic infants at 6 months (+10.7%) and 12 months of age (+8.1%).[38] In 2008, breastfeeding rates at all time points were similar among Hispanic and White infants, whereas Black infants still had lower rates.[38]

Healthy People 2020 objectives include increasing the proportion of infants ever breastfed, breastfed at 6 months, and breastfed at 12 months to 81.9%, 60.6%, and 34.1%, respectively.[40] There are also objectives to increase exclusive breastfeeding rates to 46.2% at 3 months and 25.5% at 6 months. In 2007, an estimated 16.8% of U.S. infants were exclusively breastfed for 6 months.[41]

2.3 Determinants of Breastfeeding

Predictors of breastfeeding initiation, duration, and exclusivity include racial, socioeconomic, cultural, and environmental factors.[41] A study by Jones et al. assessed predictors of being ever breastfed and breastfed exclusively for 6 months among a representative sample of US children ages 6 months to 5 years in the 2007 National Survey of Children's Health in 2007. They found that older maternal age, good maternal mental/emotional health, two-parent (biological or adoptive) family structure, and non-smoking household were significantly associated with higher rates of both breastfeeding practices.[41] Children born to mothers who attained education beyond high school were more likely to ever be breastfed (81.3% vs. 66.0% for less than high school education, $P < .001$), but differences in 6 month exclusivity rates (17.9% vs. 15.9%) did not reach significance ($P = .06$). Race/ethnicity, mother's birth in a foreign country, residence within a metropolitan area, and household poverty status were all associated with ever being breastfed, but not being breastfed exclusively for 6 months. In this study, Hispanic and non-Hispanic "other race" children were most likely to ever be breastfed (81.8% and 81.2%, respectively), with non-Hispanic black children being least likely (55.5%). Children of foreign-born mothers were more likely to ever be breastfed compared with children of U.S.-born mothers (89.6% vs. 72.6%). Of children with household income ≥ 400% of the federal poverty line, 82.9% were ever breastfed, compared with just 64.1% of those below the poverty line.

The relationship between birth weight and breastfeeding was complex in this study population.[41] Children with birth weights less than 1500g were the most likely to ever be breastfed (85.3%), but also the least likely to be exclusively breastfed for 6 months (6.7%). In comparison, among children with birth weights ≥2500g, 75.8% were ever breastfed and 17%

were exclusively breastfed for 6 months. After multivariable adjustment, odds of ever being breastfed were significantly reduced by the following factors: lower maternal education, non-Hispanic black race, two-parent (step) family structure, single mother, household income below the federal poverty line, the presence of a smoker in the household, and residence outside of a metropolitan area. Child birth weight <1500g and having a foreign-born mother were associated with increased odds. In the multivariable model, mother's age and mother's mental/emotional health were no longer significantly associated with ever being breastfed. With regard to exclusivity of breastfeeding for 6 months among those ever breastfed, the following factors were associated with significantly reduced odds ratios: mother's age ≤20 years, mother's mental/emotional health rated fair or poor, birth weight <1500g, and 2-parent (step) family structure. No other predictors were significantly associated with being exclusively breastfed for 6 months.[41]

Environmental exposures, such as health care practices and policies, may influence maternal decisions on infant feeding.[42-44] Delivery by Cesarean section has been associated with lower rates of early breastfeeding. In a 2012 meta-analysis, odds of breastfeeding initiation or breastfeeding at hospital discharge was significantly reduced among women who delivered by C-section compared with those who delivered vaginally (OR: 0.57; 95% CI, 0.50-0.65; P <.001).[42] Subgroup analyses revealed that the association appeared to be limited to pre-labor (elective) C-sections but not emergency C-sections. Among women who initiated breastfeeding, there was no significant association between type of delivery and breastfeeding at 6 months.

The popular practice of providing new mothers with discharge bags containing formula samples has been associated with reduced odds of exclusive breastfeeding at 10 weeks and 6 months.[43] The removal of formula packs from discharge bags at one hospital was associated with

increased rates of any breastfeeding, but not exclusive breastfeeding, at 10 weeks.[44] The practice of distributing formula to maternity patients at discharge appears to be declining, but remains prevalent.[45]

Other healthcare practices that influence breastfeeding success in the neonatal period are targeted by the *Ten Steps to Successful Breastfeeding*, developed as part of the global Baby Friendly Hospital Initiative (BFHI) launched by UNICEF and WHO in 1991.[46] The *Ten Steps* components include early skin-to-skin contact between mother and infant,[47] avoidance of supplemental feedings,[48] access to any breastfeeding support[49] or education,[50] and access to lactation consultants specifically.[51] In order to attain a designation as a "Baby-Friendly" facility, hospitals and birthing centers must adhere to all ten steps, outlined in Table 1.2. Several studies have assessed the impact of the BFHI, or of individual baby-friendly practices, on breastfeeding rates in the U.S.[48,52] One study compared changes in breastfeeding practices at 13 hospitals that became BFHI accredited to 19 matched facilities in 4 states.[52] Although there were no overall differences in breastfeeding between BFHI and non-BFHI hospitals, there were significant improvements among mothers with lower education only. In this population, breastfeeding initiation increased by 3.8 percentage points (P =.05) and exclusive breastfeeding for ≥ 4 weeks increased by 4.5 percentage points (P =.02) at BFHI facilities, compared with non-BFHI facilities. Baseline initiation rates ranged from 22% to 58% among lower-education mothers delivering at BFHI hospitals. Evidence also supports positive effects of individual BFHI components on breastfeeding outcomes; specifically, avoiding breast milk substitutes or other liquids, practicing rooming-in, and breastfeeding on demand.[53] Research on pacifier use is inconclusive.[54]

Maternal overweight or obesity may also be a negative predictor of breastfeeding success.[55-57] Reviews by Tursckin et al.[55] and Amir and Donath[56] found that, overall, maternal overweight and/or obesity was associated with a reduced likelihood of breastfeeding initiation and shorter duration of breastfeeding. Interestingly, one U.S. study found that maternal obesity was associated with shorter duration of exclusive breastfeeding among Hispanic women, but not Black women, in the United States.[58] Two studies of body satisfaction and breastfeeding outcomes found that concern about weight or body shape was a negative predictor of breastfeeding intention, suggesting that this psychosocial factor may also be contributing to observed associations between maternal obesity and infant feeding intentions.[59,60] Biological mechanisms, though not yet well understood, have also been suggested. Several studies have observed greater odds of delayed onset of lactogenesis,[57,61-63] reduced prolactin response to suckling,[64] and less adequate milk supply[62] or perception of less adequate milk supply[65,66] among overweight or obese women compared with normal weight women.

Not surprisingly, many of the factors associated with lower adherence to breastfeeding guidelines are also associated with early introduction of solid foods,[67] A review by Wijndaele et al. (2009), summarized the findings of 78 studies reporting determinants of early introduction of solid foods or early introduction of cow's milk among populations in developed countries.[67] Strong determinants of early weaning included young maternal age, low maternal education, low socioeconomic status, no breastfeeding or short duration of breastfeeding, maternal smoking, and lack of information or advice from health care provider.

Table 1.2. The Baby-Friendly Hospital Initiative's Ten Steps to Successful Breastfeeding[46]
1. Have a written breastfeeding policy that is routinely communicated to all health care staff. 2. Train all health care staff in the skills necessary to implement this policy. 3. Inform all pregnant women about the benefits and management of breastfeeding. 4. Help mothers initiate breastfeeding within one hour of birth. 5. Show mothers how to breastfeed and how to maintain lactation, even if they are separated from their infants. 6. Give infants no food or drink other than breast-milk, unless medically indicated. 7. Practice rooming in - allow mothers and infants to remain together 24 hours a day. 8. Encourage breastfeeding on demand. 9. Give no pacifiers or artificial nipples to breastfeeding infants. 10. Foster the establishment of breastfeeding support groups and refer mothers to them on discharge from the hospital or birth center.

2.4 Breastfeeding and Health Outcomes

It is now widely accepted that breast milk is the ideal food for infant health and development. However, the precise number and magnitude of the risks posed by formula use remain controversial, particularly in developed countries. A 2007 review by the U.S. Agency for Healthcare Research and Quality (AHRQ) provides a comprehensive summary of evidence for associations between breastfeeding and numerous maternal and infant health outcomes.[36] The meta-analyses conducted by AHRQ suggest a protective effect of breastfeeding on the following health outcomes in full-term infants: acute otitis media, atopic dermatitis, non-specific gastroenteritis, and hospitalization due to lower respiratory tract diseases. Breastfeeding was also associated with reduced risks of obesity in adolescence and adulthood, type 1 diabetes, type 2 diabetes, and sudden infant death syndrome (SIDS). However, the associations for obesity, and type 1 and type 2 diabetes should be interpreted cautiously because of the potential for residual confounding and/or recall bias in the studies included. Results were equivocal for asthma, cognitive development, cardiovascular disease, childhood leukemia, and infant mortality. For preterm infants, a small but statistically significant reduction in risk of necrotizing enterocolitis

among infants fed breast milk vs. formula. There was no good evidence for an impact of breastfeeding on cognitive development in preterm infants. With regard to maternal outcomes, there were significant protective associations between breastfeeding and maternal type 2 diabetes among women without a history of gestational diabetes only; postpartum depression, though it is possible that postpartum depression preceded the cessation of breastfeeding; breast cancer; and ovarian cancer.

CHAPTER 3

WEIGHT GAIN IN INFANCY

3.1 Weight Gain in Infancy and Health Outcomes

Whereas obesity in children and adolescents has been convincingly linked to a wide range of adverse health outcomes,[68] comparatively less is known about the long-term effects of excess weight or excess weight gain in infancy. There is, however, emerging evidence that higher weight and higher rate of weight gain during the first year of life is associated with increased risk of obesity in later childhood[69-71] and both adiposity[8,72] and adverse metabolic risk profile[8] in adulthood. If the trajectory to obesity begins as early as infancy, as data suggests, early life nutritional factors that may modify that risk need to be identified. Those protective factors could then be used to inform interventions that can be targeted to the general population or sub-groups at increased risk.

Flores et al. identified several significant predictors of overweight in kindergarten in their 2013 study using prospective cohort data from 6800 U.S. children who were followed from birth to kindergarten entry.[71] Having a weight-for-length value $\geq 85^{th}$ percentile at 9 months or 2 years of age, or at preschool age, were significantly associated with overweight at kindergarten entry, after adjustment for race/ethnicity, language spoken in the home, and number of children in the household. BMI $\geq 85^{th}$ percentile at 9 months was associated with a 70% increased risk.

In 2014, Gittner and colleagues reported results of a similar study with a retrospective chart review design.[70] They found that the BMI patterns of 221 children categorized as normal weight, overweight, obese, and severely obese at age 5 began to diverge as early as 4 months of age and remained significantly different at each of 7 subsequent time points to age 5 years. All of these children had birth weights that were appropriate for gestational age (AGA); therefore, the

findings of this study cannot be generalized to infants born small for gestational age (SGA) or large for gestational age (LGA).

A meta-analysis of 10 cohort studies in 6 countries by Druet et al.[69] sought to describe the association between infant weight gain and risk of childhood and adult obesity. The study included data from 47, 661 individuals and found that each 1-unit increase in standard deviation (SD) score for weight between birth and 1 year of age was associated with nearly twice the risk of obesity in childhood (measured between ages 6 and 14) and a 23% higher risk of adult obesity. In a study published since that review, Odegaard and colleagues[72] found that infant weight-for-age or weight-for-length $\geq 85^{th}$ percentile and rapid weight-for-age growth during the first 24 months of life were associated with significantly increased risk of overweight in young adulthood (between ages 20 and 29 years).

The effects of excessive or rapid weight gain in infancy and early childhood may extend beyond increasing long-term risk for obesity; it may also impact other measures of cardiovascular and metabolic health.[8] In a longitudinal study of 217 healthy young adults for whom first-year growth data were available, included in the Druet et al. review,[69] Leunissen et al. found that rapid weight gain (> 0.5 SDs) in the first 3 months was associated in adulthood with reduced insulin sensitivity and HDL; and increased waist circumference, acute insulin response, total cholesterol to HDL ratio, and triglycerides.[8] These associations were adjusted for several potential confounders, including gestational age, sex, height growth, and socioeconomic status. The associations between rapid early infancy weight gain and measures of insulin sensitivity and blood lipid concentrations were not explained by adult percent body fat. The results of this study suggest that the origins of obesity and metabolic syndrome may be in very early infancy. Leunissen and colleagues did not have dietary intake data from infancy for the

study participants, so they were unable to determine whether dietary factors such as breastfeeding vs. formula feeding influence the rate of weight gain in infancy or adult obesity and cardiometabolic health.

Khuk et al. also reported a positive association between weight gain from birth to 3 months of age and risk of metabolic syndrome among 357 Chilean adolescents.[73] In this study, breastfeeding exclusively for at least the first 90 days of life was associated with reduced risk of metabolic syndrome. However, the authors did not assess the association between breastfeeding and weight gain in infancy.

3.2 Breastfeeding and Infant Weight Gain

There is now suggestive, but not conclusive, evidence that breastfeeding is associated with lower risk of obesity in childhood[36,71,74-77] and adulthood.[36,77] A 2013 WHO meta-analysis concluded that high-quality studies suggest there is likely a small protective effect of breastfeeding on obesity risk later in childhood.[76] Because both breastfeeding and weight gain in infancy are associated with risk of later obesity, it has been hypothesized that breastfeeding may alter obesity risk by influencing the rate of weight gain during the first year of life.[78] It is also possible that breastfeeding modifies the relationship between rapid infant weight gain and later obesity.[12]

At least 8 prospective cohort studies have investigated the relationship between infant milk feeding (i.e. breastfeeding or formula feeding) and the rate of gain in weight, adiposity, or other measures of growth during the first year of life, and in some cases into early childhood.[10-14,16,79,80] Six of the studies were conducted in cohorts outside the U.S.; the remaining two used the same U.S. cohort (See *Previous Studies on Infant Feeding and Infant Weight Gain in the*

U.S.).The results of these studies are relatively consistent, with most finding some association between breastfeeding and less or slower weight gain.

Baker and colleagues used a sample of 3768 mother-infant dyads from the Danish National Birth Cohort to identify predictors of greater infant weight gain.[79] The outcome of interest was absolute weight gain in grams during the first year of life and was obtained from the patient health record. Primary exposures of interest were maternal prepregnancy BMI, duration of any breastfeeding, and age at introduction of solid foods. Maternal characteristics were obtained by self-report at two time points during pregnancy and at 6 months postpartum. Infant feeding practices were assessed at 6 months and 18 months postpartum. Breastfeeding duration was categorized into quartiles (<20, 20-31.9, 32-40, or >40 weeks and age at introduction of complementary foods was divided into two categories: <16 weeks or ≥ 16 weeks. After adjustment for many potential confounders, shorter duration of any breastfeeding was significantly associated with greater weight gain ($P < .001$ for all categories) compared with >40 weeks of breastfeeding. For infants breastfed the shortest duration (<20 weeks), this difference was 317.4 g from birth to 1 year of age. Early introduction of solid foods was also associated with increased weight (+224.2 g from birth to 1 year of age), but only when breastfeeding duration was short (<20 weeks; P for interaction < .01). Other significant predictors of greater infant weight gain included primiparity, maternal smoking during pregnancy, gestational weight gain, shorter gestation duration, male infant sex, lower birth weight, and infant length at age 1 year. Strengths of this study include its large sample size and assessment of a large number of covariates. Limitations include a population that is not representative of all Danish mothers, possible recall bias with regard to infant feeding, and a lack of detail in measurement of infant feeding behaviors. Importantly, breastfeeding intensity and exclusivity were not assessed.

A similar study in a German cohort (*N*=2377 infants) did investigate duration of exclusive breastfeeding as a possible predictor of excess weight gain, defined as weight gain >90th percentile at 24 months.[10] Exclusive breastfeeding was defined as feeding breast milk without any use of infant formulas. Introduction of solid foods was analyzed separately. Compared with exclusive breastfeeding (EBF) duration of ≥ 6 months, the multivariable adjusted odds ratios for excess weight gain were 1.99 (95% CI, 1.34-2.97), 1.61 (95% CI, 1.04-2.50), and 1.40 (95% CI, 0.93-2.11) for EBF durations of 0-1 month, 2-3 months, and 4-5 months, respectively. Models were adjusted for introduction and composition of solid food, maternal BMI, maternal smoking during pregnancy, socioeconomic status, study center, birth order, and sex. The design of this study was rigorous, with data on infant feeding and other variables collected by parent-completed questionnaires on a monthly basis, and infant weight and height measurements obtained at regularly scheduled preventive medical visits. Therefore, the risks of systematic measurement error and recall bias are relatively low. This study did not, however, assess breastfeeding intensity in terms of percent of milk feedings that were breast milk.

Karaolis-Danckert and colleagues investigated the associations between infant feeding practices and change in body weight or body fat in two separate German cohorts[12,14] The first study included 249 term AGA infants.[12] The exposure of interest was duration of "full breastfeeding," defined as no additional foods or liquids other than tea or water and dichotomized as ≥ 17 weeks or < 17 weeks. Outcomes included rate of weight gain between 0 and 24 months, BMI standard deviation score (SDS) and body fat percentage at 24 months, and change in BMI SDS and body fat percentage from 2-5 years. Several interesting findings emerged from this study. Children who experienced rapid weight gain between birth and 24 months, defined as a change in weight SDS > 0.67, had significantly higher BMI SD scores and

greater body fat percentage at age 5 compared with children who experienced normal weight gain. Full breastfeeding for at least 17 weeks was not associated with rapid weight gain between 0 and 24 months; however, among rapid growers, longer full breastfeeding was associated with lower body fat percentage at age 2 (*P* for interaction = .009). This study is strengthened by its long duration of follow-up, rigorous analytical approach, and assessment of body fat in addition to weight and BMI SDS. However, it also has several limitations. Breastfeeding was not assessed until the infant was 3 or 6 months old, thus introducing the possibility of recall bias or misclassification of the exposure. Additionally, breastfeeding status was categorized rather crudely, thereby precluding any investigation of a dose-response relationship.

In a subsequent study, Karaolis-Danckert and colleagues[14] utilized the German Multicenter Allergy Study cohort to investigate the associations between intrauterine and postnatal exposures and the same outcomes assessed in the earlier study, with one exception: BMI and body fat trajectories were measured from ages 2 to 6, rather than ages 2 to 5. Bottle feeding was one postnatal exposure included in the analyses. Infants who were not breastfed or were partially breastfed for ≤ 3 months were considered to be bottle fed. All other infants were considered not bottle fed. Other exposures assessed as potential risk factors for rapid weight gain and adiposity included infant sex, BMI SDS at birth, gestational age, parity, intrauterine tobacco exposure, tobacco exposure at 1.5 years, allergy, maternal weight status, and maternal education. Factors that significantly increased risk of rapid weight gain included shorter gestation (OR, 5.12; 95% CI, 2.22-11.82, *P* < .001), being firstborn (OR, 2.01; 95% CI, 1.10-3.69, *P* =.02), and having been bottle-fed (OR, 3.02; 95% CI, 1.68-5.43; *P* < .001). Greater BMI at birth was associated with reduced risk (OR, 0.54; 95% CI, 0.38-0.77; *P* < .001). Among children who gained weight rapidly, there was an increased risk of greater gain in body fat percentage between

ages 2 and 6 for those with intrauterine tobacco exposure (*P* for interaction = .005) or an overweight mother (*P* =.007). This association was also observed for change in BMI SDS (*P* = .03 for both risk factors).

In contrast with the findings of their first study, the interaction between bottle-feeding and rapid weight gain on adiposity at age 2 was not significant after adjustment for socioeconomic characteristics.[14] This study was similar to the first in terms of sample size, population, outcome measures, and analytic approach. However, there are some methodological differences between the two. The later study assessed infant feeding initially at an earlier infant age and included repeated measures (at 1, 3, 5, and 12 months vs. a one-time assessment at 3 or 6 months in the earlier study), thereby reducing—but not eliminating—the potential for recall bias and misclassification of bottle feeding. Both studies used relatively imprecise measures of breastfeeding or bottle feeding and could not determine the effects of exclusivity or intensity of breastfeeding. Finally, selection bias is a concern in both cohorts; only subjects who had complete data for 5 or 6 years were included.

A 2008 study by Baird et al. used a sample of 1740 infants from the UK to compare infant growth—as conditional gain in weight, length, and skinfold thickness from 0-6 months and from 6-12 months—among infants who were fed mostly according to current guidelines and those who were not.[11] Milk feeding was categorized into 6 levels, defined by duration of breastfeeding and age at introduction of formula (e.g. breastfed 0-6 months; breastfed ≥ 1 month, formula started < 2 months; breastfed ≥ 2 months, formula 2-4 months, etc.). They also assessed age at introduction of solid foods and dietary pattern between 6 and 12 months of age, as determined by principal component analysis. Infant feeding practices were assessed at home visits when infants were approximately 6 months old and again at approximately 12 months.

Infant anthropometric measurements were taken by research nurses within 48 hours of birth and at the home visits at 6 and 12 months. The study found that infants who were breastfed for shorter durations and fed formula earlier experienced greater gains in weight (*P* for trend [P_{trend}] < .001), length (P_{trend} = .001), and adiposity (P_{trend} = .028) compared with infants who were only breastfed for the first 6 months of life.[11] A similar pattern was observed for absolute measures of weight, length, and skinfold thickness at 6 months of age. Milk feeding models were adjusted for age at introduction of solid foods, maternal education, parity, maternal smoking status during pregnancy, and gender. Earlier age at introduction of solid foods was not significantly associated with conditional gain in weight, length, or skinfold thickness after adjusting for other covariates; however earlier introduction of solids was associated with greater attained weight and length at 6 months of age (P_{trend} = .008 and P_{trend} = .002, respectively). Direct assessment of infant anthropometric measures is a strength of this study, as is its relatively large sample size. Categorization of breastfeeding and formula feeding into 6 levels also allowed for identification of a dose-response relationship between milk feeding and growth. However, this study, like many others, is subject to recall bias because infant feeding was not assessed until infants were 6 months old. Additionally, although the duration of breastfeeding without formula supplementation was categorized in adequate detail, there was still no assessment of breastfeeding intensity (i.e. age at introduction of formula was determined without regard to the amount of formula vs. breast milk given).

Perhaps the largest study of breastfeeding and infant weight gain to date comes from a pooled analyses of two German prospective studies by Rzehak et al. (2009)[80] This analysis included a total of 7,643 full-term healthy infants from the GINI-plus and LISA-plus birth cohorts. Breastfeeding was categorized as breastfeeding for ≥ 4 months or any other practice.

Outcomes were weight gain and BMI change velocities (units per month) during each of five segments of time between birth and 6 years of age (0-3, 3-6, 6-12, 12-24, and beyond 24 months). Rate of change in proportion of children who were overweight or obese (defined as the 90th and 97th percentile of BMI SDS according to WHO growth charts, respectively) during these same time periods was also assessed. Weight and length measurements were obtained from medical records. In the LISA-plus cohort, breastfeeding was assessed by questionnaire at 6 months of age.[81] In the GINI-plus cohort, milk feeding was documented by parents in weekly diaries throughout the infants' first 6 months of life.[82] Piecewise linear random effects regression models were used to assess individual and population growth trajectories. In the pooled analysis, Rzehak and colleagues found that infants breastfed for at least 4 months had reduced velocities of weight gain at every time period, compared with infants who were formula-fed or breastfed less than 4 months. The largest difference occurred between 3 and 6 months of age (-93 g/month). The risk of becoming overweight or obese was also slightly lower among breastfed children. However, growth in length was similar in the two groups. In most models, adjustment for maternal smoking in pregnancy, study center, and socio-economic status resulted in little change in the estimates. This study's large sample size and use of direct measurement for outcome assessment help strengthen its conclusions. Breastfeeding was assessed early and often in one of the cohorts, but rather late (at 6 months) in the other. Again, here too in this study the breastfeeding variable was crudely categorized, and as with many other studies, there was no investigation of the effects of exclusivity or intensity of breastfeeding.

Another large study published in 2014 included a sample of 4251 UK infants from the twin-based Gemini cohort.[13] In this study, duration of any breastfeeding and age at weaning were investigated as potential predictors of individual growth relative to average trajectory for weight

(in grams), weight gain velocity (grams/week), and tempo (age at peak weight velocity). Infant feeding measures were assessed by parent-completed questionnaires at baseline and first follow-up. Infant ages ranged from 4-20 months at baseline (mean 8.2 months) and from 14-27 months at follow-up (mean 15.8 months). Infant weights were obtained from the personal health record. In this study, infants who were breastfed for at least 4 months had significantly lower weight gain velocity (6.8% difference; SE= 1.3%) compared with infants who were never breastfed. Breastfed infants also reached peak weight velocity an average of one week later than non-breastfed infants (standard error = 0.2 weeks). Compared with early weaning (< 4 months), later weaning (≥ 6 months) was associated with reduced weight (mean difference 102 g, SE=25g), 4.9% lower growth velocity (SE=1.1%), and slightly slower tempo, with peak velocity occurring 0.3 weeks later than with earlier weaning (SE=0.01, *P*=0.04). Models were adjusted for clustering of twins within families, twin order, sex, zygosity, gestational age, maternal age at baseline, child age at baseline, parental occupation, maternal education, parity, maternal smoking during pregnancy, and maternal BMI. Although this study provides strong evidence for associations between longer breastfeeding and later weaning with slower weight gain in infancy, it has several limitations. Importantly, infant feeding measures were assessed late, introducing the possibility of recall bias, and the only milk feeding variable considered was duration of any breastfeeding. Again, breastfeeding intensity and exclusivity were not measured.

3.3 Previous Studies of Breastfeeding or Bottle-feeding and Infant Weight Gain in the U.S.

Two studies by Li and colleagues used the Infant Feeding Practices Study II (IFPS II) cohort, drawn from across the U.S., to describe the associations between breastfeeding practices and either excess weight or weight gain in infancy.[15,16] In the first study, the exposures of interest were breastfeeding intensity and infant bottle emptying behaviors.[15] Breastfeeding intensity was

defined as the average percent of milk feeds that were breast milk during the infant's first 6 months of life and categorized as low (<20%), medium (20-80%), or high (>80%). Mother-initiated and infant-initiated bottle emptying were assessed by responses to questions about how often the infant finishes a cup or bottle and how often the mother encourages the infant to finish the bottle if he or she stops drinking before the formula or pumped breast milk is gone. Both bottle emptying variables were categorized into 5 levels: never, rarely, sometimes, often, or always. The outcome of interest was risk of excess weight in late infancy, defined as weight-for-age *z*-score >1 after age 6 months. Infant feeding variables and weights were assessed monthly by parent-completed questionnaires approximately monthly from about 1 month of age through 12 months (10 questionnaires over 12 months). Weight-for-age *z*-scores were calculated using the Centers for Disease Control and Prevention's (CDC) growth reference.

The multivariable adjusted odds ratios for excess weight in the second half of infancy were 2.32 (1.40-3.84) and 2.11 (1.24-3.60) for low- and medium-intensity breastfeeding, respectively, compared with high intensity.[15] As expected, infant-initiated bottle emptying was positively associated with risk of excess weight in late infancy, with an odds ratio of 1.69 (95% CI, 1.09-2.63) for "often" vs. "rarely." Unexpectedly, mother-initiated bottle emptying was inversely associated with risk of excess weight; the OR for "often" vs. "rarely" was 0.49 (95% CI, 0.31-0.77). This finding likely reflects reverse causation. Mothers who perceive their infants' weight to be low may be more apt to encourage bottle emptying. Covariates included in this model were infant gender, gestational age, age at last weight measurement, birth weight, age at introduction of solid foods, intake of sweet drinks in the first half of infancy, maternal age, parity, maternal education, race/ethnicity, income, maternal prepregnancy BMI, and maternal

smoking at 3 months postpartum. The principal limitations of this study are underrepresentation of non-White mothers and infants and maternal report of infant weight measurements.

A second study by the same group of researchers used the same cohort (IFPS II) to determine whether breastfeeding intensity and frequency of bottle feeding were associated with weight gain during infancy.[16] Weight gain was assessed as grams per month at each of four intervals: birth to 3 months, >3-5 months, >5-7 months, and >7-12 months. Six feeding categories were used to describe both breastfeeding and bottle feeding practices: breastfed only, breastfed and human milk by bottle, breastfed and nonhuman milk by bottle, human milk by bottle only, human and nonhuman milk by bottle, and nonhuman milk by bottle only.

The results of linear mixed models analyses indicated that most feeding methods were associated with greater weight gain when compared with feeding at the breast only.[16] Compared with infants who were fed at the breast only, infants who were given nonhuman milk by bottle only gained 71g/month more than infants fed only at the breast ($P < .001$). Those fed human milk by bottle only gained 89 g/month more than infants fed directly at the breast ($P = .02$). Those fed human and nonhuman milk by bottle only gained 37 g more per month ($P = .08$), while infants who were breastfed and given nonhuman milk by bottle gained 45 g/month more ($P < .001$). Finally, infants who were breastfed and fed human milk by bottle gained weight similarly to infants fed at the breast only. The main effects of a 10% increase in proportion of breast milk feedings and a 10% increase in proportion of bottle feedings were a 3.6 g decrease in weight gain per month ($P = .07$) and a 4.1 g increase in weight gain per month ($P = .05$), respectively. Stratified analyses were carried out to assess the effect of bottle-feeding among infants fed only breast milk and the effect of breast milk among infants fed only by bottle. The findings of those analyses suggest that weight gain increases in a fairly linear fashion with

frequency of bottle feeding, among infants fed only breast milk. Among infants fed only by bottle, the association between percent of feedings that were breast milk and weight gain was U-shaped. Models were adjusted for maternal age, race/ethnicity, maternal education, household income, maternal marital status, parity, postpartum participation in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC), pre-pregnancy BMI, infant sex, gestational age, birth weight, age at solid food introduction, and sweet drinks consumption.

The results of this study suggest that there may be important differences in the effects of feeding at the breast and bottle feeding that are independent of the nutritional content of breast milk.[16] The studies by Li and colleagues[15,16] have some noteworthy limitations. The IFPS II cohort sample is largely non-Hispanic white, with low proportions of minority groups; therefore, the results may not be generalizable to other populations. Furthermore, infant weight measurements were self-reported and therefore subject to error. On the other hand, these studies measured infant feeding variables early, frequently, and with high precision (e.g. number of feedings per day over 7 days). Only the 2012 study assessed breastfeeding intensity, and neither assessed exclusivity of breastfeeding or likelihood of rapid weight gain as defined in prior literature.

CHAPTER 4

BREASTFEEDING AFTER GESTATIONAL DIABETES

4.1 Benefits of Breastfeeding in Women with Gestational Diabetes and Their Children

Maternal gestational diabetes mellitus (GDM), which results in an elevated supply of glucose to the fetus, is one factor that may influence infant metabolic programming prenatally. Increasing maternal glycemia during pregnancy has been positively associated with increasing risk of obesity in children at age 5-7 years.[20] Maternal GDM has also been associated with impaired glucose metabolism,[22] and children born large for gestational age to women with GDM appear to be at especially high risk.[21] Although some of these associations may be explained by genetics, it has been proposed that fetal hyperinsulinemia and hyperleptinemia, in response to increased available glucose concentrations, may induce changes in the hypothalamus and pancreas that lead to impaired appetite regulation and/or insulin secretion in the offspring.[23]

Breastfeeding has been found to have particular benefits for both women with a history of GDM and their infants.[19,83-86] Several cross-sectional and cohort studies have suggested a benefit of breastfeeding for short-term insulin sensitivity and glucose homeostasis among postpartum women with[87-90] or without a history of GDM.[91] Less is known about the long-term effects of breastfeeding on glucose homeostasis. At least 6 studies have attempted to determine whether the metabolic benefits of breastfeeding persist after lactation ceases.[84,92-96] Two retrospective studies[92,94] with varying follow-up times up to 7 or 14 years and one longitudinal study with a follow-up time of 11-24 months postpartum[93] found no difference in type 2 diabetes rates or oral glucose tolerance test (OGTT) results according to breastfeeding history. On the other hand, a prospective study by Ziegler et al.[95] found that breastfeeding, especially longer duration (>3 months) of breastfeeding, was associated with lower long-term risk of developing type 2

diabetes. Among women who were negative for islet autoantibodies, those who breastfed for more than 3 months had a 15-year risk of developing type 2 diabetes of 42% [95% CI, 28.9–55.1], compared with 72% [95% CI, 60.5–84.7] ($P < .001$) for women with no or ≤3 months of breastfeeding. Another cross-sectional study of Canadian women found that women who had reported (retrospectively) breastfeeding for more than 10 months had improved insulin sensitivity and glucose tolerance at 1-7 years postpartum.[96] More prospective studies with longer follow-up, larger sample size, and adjustment for potential confounders are needed to elucidate the association between breastfeeding among women with a history of GDM and later risk of type 2 diabetes. In the meantime, evidence is suggestive of at least a short-term beneficial effect of breastfeeding on glucose homeostasis.

Although inconclusive, a few studies have also found a protective association between breastfeeding and type 2 diabetes risk among offspring of women with GDM.[24-26] Schaefer-Graf and colleagues reported an adjusted odds ratio for overweight in early childhood (ages 2-8) of 0.55 [95% CI, 0.32-0.85, $P = .01$) for children born to women with GDM who were breastfed more than 3 months, compared with those who were breastfed for up to 3 months.[24] In their case-control study, Young and colleagues also observed a substantial reduction in risk of type 2 diabetes among native Canadian youth who were breastfed more than 12 months (OR: 0.24; 95% CI, 0.13-0.99).[26]

Most recently, Crume et al. showed that BMI trajectories were significantly lower during infancy (birth to age 24 months) and childhood (ages 2 to 14 years) for children born to mothers with gestational diabetes who were breastfed "adequately" compared with those who were not.[97] This study was a retrospective cohort of children born at a single hospital in Denver, Colorado. The sample included 94 children from gestational diabetic pregnancies and 399 from nondiabetic

pregnancies. The influence of breastfeeding status on BMI trajectory was similar for children with and without exposure to gestational diabetes in utero. In this study, adequate breastfeeding was defined as ≥ 6 "breast milk-months." The variable "breast milk-months" was calculated as a composite variable that accounted for exclusivity and duration of breastfeeding.

4.2 Breastfeeding Practices among Women with GDM

Despite the established benefits of breastfeeding for all women and infants, and the possible benefits for women with GDM and their offspring in particular, there is some evidence that breastfeeding rates may be lower among women with GDM.[98,99] A prospective German study compared breastfeeding practices of postpartum women with or without GDM (n=257 and n=527, respectively) who enrolled in the BABYDIAB study between 1989 and 2000.[99] This study found that breastfeeding initiation was lower in the GDM group (75% vs. 86%, P <.001). Among those who initiated breastfeeding, median duration of full breastfeeding was also lower for GDM vs. no GDM (9 vs. 17 weeks, P < .001), as was the median duration of any breastfeeding (16 vs. 26 weeks, P < .001).

Finkelstein et al. used a retrospective design to assess breastfeeding among women with pre-gestational (insulin-treated or non-insulin-treated) and gestational diabetes who gave birth in 4 hospitals in Ontario, Canada.[100] For women with gestational diabetes compared with women without diabetes, the adjusted ORs for exclusive breastfeeding in the hospital and at discharge were 0.77 (95% CI, 0.68-0.87) and 0.75 (95% CI, 0.66-0.85), respectively. There were no differences between these groups in terms of intention to breastfeed (OR: 0.98; 95% CI, 0.78-1.22). For all three measures (intention, breastfeeding in hospital, and breastfeeding at discharge), women with either form of pre-gestational diabetes had significantly reduced rates

compared with women without diabetes. Furthermore, all ORs for insulin-treated diabetes were lower than those for non-insulin-treated pre-gestational diabetes.

Finally, Oza-Frank and colleagues examined differences in breastfeeding initiation and continuation (defined as continuing to breastfeed for at least 2 months) between women with and without a history of GDM using cross-sectional data from the U.S. Centers for Disease Control and Prevention's Pregnancy Risk Assessment Monitoring System (PRAMS), 2009-2011.[98] Of 72,755 women included in the study, 8.8% had GDM and 1.7% had pregestational diabetes (PDM). Although breastfeeding initiation rates were similar among women with and without GDM (80.8% vs. 82.2%, $P = .20$), continuation was lower among GDM women (65.7% vs. 68.8%, $P = .01$). Women with PDM were less likely to initiate 78.2%, $P = .03$) or continue breastfeeding (60.4%, $P < .01$) compared with those with no gestational diabetes.

Two of these three previous studies examining breastfeeding rates among women with GDM have lacked either a prospective design or a long duration of follow-up, thereby limiting the extent to which differences in duration of breastfeeding can be assessed. Only Hummel et al. measured exclusivity of breastfeeding and included a follow-up of several months.[99] To date, few if any long-term prospective studies in the U.S. have assessed breastfeeding behaviors among women with GDM.

4.3 Factors Influencing Breastfeeding among Women with GDM

4.3.1 Physiologic Factors Influencing Breastfeeding among Women with GDM

The precise reasons for reduced breastfeeding rates among women with GDM pregnancies are not clear, and there are many possible explanations. Women with GDM also more frequently have other risk factors for suboptimal breastfeeding, including obesity[101] and

higher C-section rates.[102] On the other hand, increasing maternal age is a risk factor for GDM[103] but is generally associated with increased breastfeeding.[41]

While little is known about the factors influencing breastfeeding among women with GDM, comparatively more is understood about the challenges faced by obese mothers, who are more likely to develop GDM.[101] Kim and colleagues have estimated that close to half (46.2%) of all GDM cases in the U.S. are attributable to excess weight (overweight and obesity combined).[104] When compared to normal-weight mothers, obese mothers have significantly shorter durations of breastfeeding.[105,106] In a large prospective cohort of Danish women (N=37,459), Baker and colleagues observed increasing risk of termination of any breastfeeding with increasing prepregnancy BMI, with relative risks ranging from 1.12 (95% CI, 1.09-1.15) to 1.39 (95% CI, 1.19-1.63) for overweight and class III obesity (BMI ≥ 40), respectively.[105] Oddy et al. studied an Australian cohort and found similar increased odds of breastfeeding < 2 months (adjusted OR, 1.89; 95% CI, 1.45-2.47), < 4 months (adjusted OR, 1.95; 95% CI, 1.51-2.51) and < 6 months (adjusted OR, 1.76; 95% CI, 1.35-2.28) for overweight or obese women compared to normal-weight women.[106] However, the rates of ever breastfeeding were not significantly different between BMI groups.[106]

Both obese women[28,107] and women with any form of diabetes during pregnancy[28,29] are more likely to experience delayed onset of lactation, defined as onset of copious milk production > 72 hours postpartum.[29] Reduced prolactin response to suckling in overweight/obese women has been observed and may contribute to this phenomenon.[108] Obese women may have larger breasts or flatter nipples, both of which can make it more difficult for an infant to latch properly to the breast and remove milk effectively.[109]

Women with diabetic pregnancies may face additional threats to successful breastfeeding compared to non-diabetic obese women. Women with poorer glucose control—as evidenced by treatment with insulin vs. oral hypoglycemic medication—are more likely to have DOL than diabetic women with less severe diabetes.[28] Furthermore, among women with insulin dependent diabetes mellitus (IDDM), those with poorer metabolic control were more likely to experience DOL.[110] That more severe diabetes is more strongly associated with DOL suggests that the metabolic disturbances of diabetes may have an independent adverse effect on lactation.

A study by Kachoria and Oza-Frank also supports an effect of maternal diabetes on breastfeeding that is separate from the effect of BMI.[111] Their study included data from 792,730 births in Ohio between 2006 and 2011. They compared factors associated with breastfeeding by maternal diabetes status (no diabetes, gestational diabetes, or prepregnancy diabetes). Among mothers without diabetes, all BMI categories associated with reduced odds of breastfeeding at hospital discharge, compared to normal weight mothers. However, among women with GDM, overweight was no longer significantly associated with breastfeeding (adjusted OR, 0.9; 95% CI, 0.9-1.0), but underweight (adjusted OR, 0.7; 95% CI, 0.6-0.9) and obesity (adjusted OR, 0.9; 95% CI, 0.8-0.9) remained significant. Among women with prepregnancy diabetes, there was no effect of BMI on breastfeeding at discharge.

Neonatal hypoglycemia, which affects 10-25% of infants born to diabetic mothers, is another factor that may influence breastfeeding outcomes among GDM women.[112] Although both the AAP[113] and the Academy of Breastfeeding Medicine[114] both recommend intravenous glucose and frequent feedings at the breast for hypoglycemic neonates, supplemental formula feedings may also be used. The World Health Organization includes neonatal hypoglycemia in its list of "Acceptable Medical Reasons for Use of Breast-Milk Substitutes," but only "if [the

infant's] blood sugar fails to respond to optimal breastfeeding or breast-milk feeding."[115] There are little to no data on actual hospital practices for managing neonatal hypoglycemia, so it is unclear whether this condition contributes substantially to formula use among infants of women with GDM.

We are aware of only one study that has examined factors contributing to breastfeeding outcomes in women with GDM. Morrison and colleagues identified several factors associated with early cessation of breastfeeding, defined as ≤ 3 months, among Australian women with recent GDM.[116] They found that breastfeeding problems at home (adjusted OR, 8.01; 95% CI, 4.57-14.05) and inadequate breastfeeding support (adjusted OR, 1.88; 95% CI, 1.10-3.22) were predictive of early cessation of breastfeeding. Other significant factors were maternal BMI, socioeconomic status, marital status, return to work < 3 months postpartum, and Cesarean delivery. However, because Morrison et al. did not compare women with GDM to nondiabetic women, it is not known whether these factors are disproportionately prevalent in GDM.

4.3.2 Psychosocial Factors Influencing Breastfeeding among Women with GDM

Ajzen's Theory of Planned Behavior (TPB) can be used as a framework for understanding breastfeeding behavior.[117] In brief, the TPB is predicated on the notion that behavioral intention predicts behavior, and that the primary contributors to intention are attitude toward the behavior ("the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question"), subjective norm ("perceived social pressure to perform or not to perform the behavior"), and perceived behavioral control ("the perceived ease or difficulty of performing the behavior" which reflects "past experience as well as anticipated impediments and obstacles").[118] Actual behavioral control, which represents factors outside the individual that can influence behavior independently of intention, is also included.

Research suggests that the TPB is particularly well-suited to understanding breastfeeding behaviors. Constructs of the TPB have been found to predict infant feeding intentions[33,119,120] Breastfeeding intentions are strong predictors of breastfeeding behavior,[33,51] and attitudes toward breastfeeding are predictive of both intentions[32] and behavior[30] Stuebe and Bonuck have demonstrated that knowledge, attitudes and beliefs about breastfeeding are associated with intent to exclusively breastfeed in an urban, largely Hispanic population.[32] In their study, women who agreed with statements that breastfed babies are less likely to get ear infections, respiratory infections, or diarrhea, and are less likely to become obese were 6 to 7 times more likely to plan to exclusively breastfeed. Women who disagreed with the statement "infant formula is as good as breastmilk" (adjusted OR, 3.44; 95% CI, 1.80-6.59) and agreed with the statement "babies should be fed only breastmilk for the first 6 months" (adjusted OR, 7.54; 95% CI, 3.21-15.78) were also substantially more likely to intend to breastfeed exclusively.

Scott et al. also reported a significant association between maternal infant feeding attitude, as measured by the Iowa Infant Feeding Attitude Scale (IIFAS), and breastfeeding at hospital discharge (adjusted OR, 1.16; 95% CI, 1.09-1.24).[30] The IIFAS includes 17 items assessing the respondent's level of agreement, on a 5-point scale, with statements about the relative benefits and drawbacks of breastmilk vs. formula. Although paternal IIFAS score was not independently associated with infant feeding outcome, paternal and maternal scores were highly correlated ($P<.001$).

Bai and colleagues found that attitude toward breastfeeding and subjective norm—perceptions of others' agreement that babies should be exclusively breastfed for 6 months—were significantly correlated with intention to exclusively breastfeed for 6 months,[33] suggesting that

the opinions of members of a mother's social group may be an important determinant of her feeding intentions.

Concern about weight or body shape has been inversely associated with breastfeeding intention.[59,60] Hauff and Emerath have suggested that lack of body comfort or confidence postpartum may partially mediate the relationship between high prepregnancy BMI and reduced duration of breastfeeding.[121] In their study, which followed a cohort of 257 women from a single metropolitan area in the U.S., overweight/obese women had similar intentions for breastfeeding duration as normal-weight women, but their actual breastfeeding duration was significantly reduced (median duration 38.6 weeks vs. 48.9 weeks, P <.01) and risk of cessation was increased throughout the first year after their infant's birth (hazard risk [HR], 1.43; 95% CI, 1.02-2.01). The effect of BMI was slightly attenuated after adjusting for body comfort/confidence at 4 months postpartum (HR, 1.31; 95% CI, 0.93-1.86).

Related to perceived social norms and body confidence, breastfeeding in public may contribute to increased breastfeeding duration.[30] In their European cohort study, Scott et al. found that mother who had ever breastfed in public had substantially reduced risks of discontinuing breastfeeding within 12 months.[30] Compared to multiparas who had never breastfed in public, adjusted ORs for primiparas and multiparas who reported breastfeeding in public were 0.50 (95% CI, 0.30-0.81) and 0.47 (0.29-0.77), respectively. Primiparous mothers who had not breastfed in public were not significantly less likely to discontinue breastfeeding as compared to their multiparous counterparts (adjusted OR, 0.66; 95% CI, 0.41-1.06).

In the study by Stuebe and Bonuck,[32] women who were comfortable breastfeeding in front of other people were more likely to plan to exclusively breastfeed. Comfort breastfeeding in front of close women friends (adjusted OR, 1.77; 95% CI, 1.26-2.49), in front of men and

women the mother is close to (adjusted OR, 1.72; 95% CI, 1.27-2.32) and in public (adjusted OR, 1.63; 95% CI, 1.16-2.30) were all associated with increased odds of planning to breastfeed exclusively vs. mixed feeding.

CHAPTER 5

PURPOSE OF THE STUDY

There is growing evidence that rapid postnatal weight gain is associated with greater risk of obesity in childhood[69-71] as well as adiposity and metabolic risk profiles in adulthood. Breastfeeding has been associated with reduced risk of excess weight and lower monthly weight gain during infancy, but to our knowledge the association between breastfeeding intensity or exclusive breastfeeding duration and rapid weight gain in the first 12 months of life has not yet been fully investigated in a U.S. population. The first study in this series investigates the association between exclusive breastfeeding duration, breastfeeding intensity, and risk of rapid weight gain from birth to 12 months of age.

Infants born to women with gestational diabetes may be at particularly increased risk of obesity and insulin resistance, while women with a history of GDM are at greater risk of developing type 2 diabetes. Some evidence suggests that breastfeeding may improve outcomes for both women with GDM and their infants, but relatively little describing the breastfeeding practices and attitudes of women with GDM. The second study compares breastfeeding behaviors and intentions of women with GDM and women with healthy pregnancies.

Despite some evidence that GDM women breastfeed at a reduced rate, there is sparse literature offering possible explanations for this phenomenon. Physiologic, psychosocial, and environmental factors can contribute to individual breastfeeding intentions and practices. These include breastfeeding knowledge, attitudes, and beliefs about breastfeeding; perception of social support for breastfeeding; timing of lactation; hospital experiences; and early problems with breastfeeding. The third study compares these factors among women with and without GDM.

5.1 Specific Aims and Hypotheses

Aim 1

To determine the associations between exclusive breastfeeding duration and breastfeeding intensity and odds of rapid weight gain during infancy in a sample of healthy mother-infant dyads in the U.S.

Hypothesis

We hypothesized that longer duration of exclusive breastfeeding and greater breastfeeding intensity (percent of milk feeds that were breast milk) will each be associated with reduced odds of rapid weight gain during infancy in healthy mother-infant dyads in the U.S.

Aim 2

To identify differences in breastfeeding intentions and practices between women with and without a recent history of gestational diabetes in a sample of healthy mother-infant dyads in the U.S.

Hypothesis

We hypothesized that women with a recent history of gestational diabetes would be less likely to intent to breastfeed, would be less likely to initiate any or exclusive breastfeeding, and would have shorter durations of any and exclusive breastfeeding, compared with women who had not had gestational diabetes.

Aim 3

To identify differences in prenatal psychosocial factors (knowledge, attitudes, beliefs) and postnatal experiences related to breastfeeding between women with and without a recent history of gestational diabetes in a sample of healthy mother-infant dyads in the U.S.

Hypothesis

We hypothesized that women with GDM would have less knowledge of breastfeeding benefits and less favorable attitudes toward breastfeeding. We also hypothesized that women with GDM would report hospital experiences less conducive to breastfeeding and would experience more breastfeeding problems in the first 2 weeks postpartum, compared with women without GDM.

5.2. Rationale and Significance of the Study

It is becoming increasingly certain that the path to obesity and its associated metabolic disturbances begins well before these outcomes are physiologically evident; the prenatal and postnatal nutrition environment may be a particularly important influence. Although many previous studies have investigated the relationship between breastfeeding and obesity or weight gain in infancy (a marker of obesity risk), most have been limited by imprecise and potentially biased measures of breastfeeding and have focused on populations outside the U.S. The studies conducted in the U.S. have utilized more precise measures of breastfeeding, but have not used risk of rapid weight gain (change in weight-for-age *z*-score of >0.67 according to WHO growth charts) as the outcome measure, potentially resulting in misclassification. In the first U.S. study,[15] the outcome was risk of excess weight in the second half of infancy, which was defined using CDC growth charts.

The current recommendation of the CDC is that WHO growth charts be used to assess growth in infants and children under age 2 years.[122] The WHO growth charts were developed using data from the WHO Multicentre Growth Reference Study (MGRS), which included children in 6 international sites, including one in the U.S.[123] All sites selected had a socioeconomic status that would not adversely affect children's growth. All children in the MGRS were predominantly breastfed for at least 4 months and were still breastfed at 12 months of age. The MGRS also excluded children who were exposed to factors that could alter their

normal growth pattern (e.g. preterm birth, early introduction of complementary foods, maternal smoking during pregnancy or lactation, low socioeconomic status). The CDC growth charts were constructed using data from several U.S. data sources.[122] The only exclusion criterion was very low birth weight (<1,500 g). The WHO growth charts are preferred for use in clinical settings because they reflect normal growth in healthy, breastfed children, whereas the CDC growth charts reflect growth in predominantly formula-fed infants, some of whom who may have experienced other growth-altering conditions.[122]

Defining excess weight according to CDC growth charts may have underestimated the number of infants who had excess weight at the end of infancy because the CDC growth charts were developed using growth data from a sample of largely formula-fed infants, who tend to gain more weight compared with their breastfed counterparts.[122]

Furthermore, prior studies that have used the CDC growth charts to assess infant growth may have failed to identify infants who gained weight rapidly but did not reach the "excess weight" threshold as having an undesirable outcome. Literature suggests that rapid weight gain, defined as change in weight-for-age or weight-for-length z-score of >0.67, is more strongly associated with long-term obesity risk compared with static measures of weight.[72]

The second U.S. study used rate of weight gain in grams per month as the outcome, an approach that has its own limitations.[16] Because this measure was not standardized according to any growth reference or compared to the expected growth during each time interval, it is impossible to know whether infants who experienced a greater amount of weight gain on average were actually gaining weight excessively. Therefore, the first study examined associations between breastfeeding (duration of exclusive breastfeeding and breastfeeding intensity) and odds of rapid weight gain as defined by WHO growth standards.

There is now substantial evidence that breastfeeding is beneficial for women with gestational diabetes and their infants, but some studies suggest that women with gestational diabetes do not breastfeed to the same extent as women without GDM. Very few studies have examined the breastfeeding practices of women with GDM pregnancies or attempted to identify when and how the infant feeding behaviors of women with and without GDM diverge. The second study sought to answer these questions by comparing intentions to breastfeed at all or exclusively, initiation of any or exclusive breastfeeding, and duration of any or exclusive breastfeeding in women with GDM and nondiabetic women.

It is also not clear why women with GDM seem to breastfeed less than other women. The third study identified differences between women with GDM and nondiabetic women in infant feeding attitudes during pregnancy and experiences in the neonatal period that could contribute to differences in breastfeeding intentions and practices.

CHAPTER 6

MATERIALS AND METHODS

6.1 Study Design

We conducted a secondary data analysis of the Infant Feeding Practices Study II. The IFPS II was a longitudinal cohort study conducted by the US Food and Drug Administration (FDA) with the Centers for Disease Control and Prevention (CDC).[124] Women were enrolled in the third trimester of pregnancy and followed until their infant's first birthday. All data were collected between May 2005 and June 2007 by mailed questionnaires and one birth screener after delivery. A total of 4,902 pregnant women were enrolled in the study and approximately 1,808 remained in the study through the infant's first year. We included women and infants with complete data for the predictor and outcome variables for each of our respective research questions.

6.2 Study Population and Sample

A national consumer opinion panel including >500,000 households was used as the sampling frame for the IFPS II.[124] Additional information about this panel has not been made available by the IFPS II research team. The researchers sampled from this group in order to identify women who would likely be willing to complete multiple repeated questionnaires. All women who were in their third trimester of pregnancy during the 8-month recruitment period were mailed a prenatal questionnaire (n=14,618) (Appendix A). Of these, 601 were not eligible, 46 refused to participate, and 9,069 did not return the questionnaire. Those who responded and were not disqualified from participation (n=4,902) were then screened for eligibility after delivery with a brief phone interview. Thus, the response rate for the prenatal questionnaire when excluding individuals who were disqualified or could not be reached by mail was approximately

35%. The adjusted response rates for subsequent questionnaires were higher: 82.9% for the birth screener and 76.9% for the neonatal questionnaire. **Eligibility criteria** included: maternal age at least 18 years at delivery; mother and infant in generally good health; infant gestational age at birth ≥ 35 weeks; infant birth weight ≥ 5 lbs.; singleton birth; no health problem that would interfere with normal feeding.

6.3 Measurement of Key Variables

All variables were self-reported and collected from a series of mailed questionnaires. All questions were developed by the FDA and CDC with expertise in the topics included.[124] Many items were drawn from the IFPS I. New questions were extensively tested in cognitive interviews. The questionnaires were also pilot tested with respondents from the consumer opinion panel from which the IFPS II sample was drawn.

6.3.1 Assessment of Breastfeeding Behaviors

Breastfeeding was assessed by every postnatal questionnaire. The neonatal questionnaire (Appendix A) included questions about whether the mother ever attempted to breastfeed her infant; whether the infant was given any water, formula, or sugar water in the hospital; and the feeding method at discharge (breastfeeding only, formula only, or breastfeeding and formula). Exclusive breastfeeding at hospital discharge was defined on the basis of these questions.

Both the neonatal questionnaire and each subsequent postnatal questionnaire measured breastfeeding and other feeding behaviors with a food frequency chart. Respondents were asked to indicate the number of feedings given per day or per week for each of several categories of milk (breast milk, formula, cow's milk, or other milk) and other foods and beverages (baby cereal, other cereals and starches, dairy foods, 100% juice, sweet drinks, fruit, vegetables, French fries, meats, fish or shellfish, peanut butter or nuts, eggs, sweet foods, and other). All

questionnaires used for the IFPS II can be found at the study website (http://www.cdc.gov/ifps/questionnaires.htm).

6.3.1.1 Assessment of Breastfeeding Initiation

Breastfeeding initiation was determined by the variable in the dataset labeled "ever breastfed." This variable is dichotomous (0=no, 1=yes); observations were coded as "yes" if the mother indicated that she ever breastfed or tried to breastfeed, or if any food frequency charts indicated that breast milk was given.

6.3.1.2 Assessment of Breastfeeding Duration

Each postnatal questionnaire included a question asking the mother if she had stopped breastfeeding. If she answered yes, she should have also completed a module including questions about her reasons for stopping and the age of the infant when she completely stopped breastfeeding. The age reported by the mother was used to indicate breastfeeding duration. If the mother indicated she had stopped breastfeeding but did not indicate the infant's age, this value was imputed as either the infant's age at the time of the questionnaire in which the mother first indicated she had stopped breastfeeding, or as the midpoint between the infant's ages at that questionnaire and the prior questionnaire. If the food frequency chart on the questionnaire indicated that the infant received breast milk, then the former strategy was used for imputation. If the food frequency chart indicated no breast milk was given, then the latter approach was used.

6.3.1.3 Assessment of Exclusive Breastfeeding Duration

The IFPS II dataset contains dichotomous variables for exclusive breastfeeding for the hospital stay and for each questionnaire. An infant was considered exclusively breastfed during the hospital stay if the infant received breast milk and no water, sugar water, or formula. For each of the postnatal questionnaires, the food frequency checklist was used to define exclusive breastfeeding. Infants who received breast milk but no other foods were considered to be exclusively breastfed.

Duration of exclusive breastfeeding, in weeks, was estimated as the midpoint of the infant age between the last questionnaire when exclusive breastfeeding was indicated and the questionnaire when the infant was no longer exclusively breastfed. The variable is cumulative across questionnaires; in order to be considered exclusively breastfed at any time point, the infant must have been exclusively breastfed at every prior time point.

6.3.1.4 Assessment of Breastfeeding Intensity

Breastfeeding intensity was operationalized as the percent of milk feeds that were breast milk at each time point (i.e. number of breast milk feedings divided by the sum of feedings from breast milk, formula, cow's milk, and other milks * 100).

6.3.2 Assessment of Infant Weight Gain

Infant weights were reported by mothers at the birth screener (birth weight) and at months 3, 5, 7, and 12. The questionnaires asked what the infant's weight was when measured at the last doctor's visit and the infant's age at the time of that visit. We calculated weight-for-age *z*-scores from these two values using the WHO anthro macro for Stata (http://www.who.int/childgrowth/software/en/).

We recoded as missing any single weight-for-age *z*-score (WAZ) that is <5 or >5, in accordance with previous research.[15] We then calculated change in WAZ from birth to 12 months by subtracting the WAZ at birth from WAZ at 12 months. A variable for rapid weight gain was created. WAZ change scores of >0.67 were coded "1" for rapid weight gain; all other non-missing values were coded "0."

6.3.3 Assessment of Maternal Gestational Diabetes

Maternal gestational diabetes was measured by a single item in the prenatal questionnaire. The question asked respondents whether they had been diagnosed with gestational diabetes in this pregnancy. Because gestational diabetes screening tests are typically performed between 24 and 28 weeks' gestation,[125] and the prenatal questionnaire targeted women at 28-32 weeks' gestation,[124] it is expected that most respondents would have had this screening done by the time they completed the questionnaire. Respondents who indicated a diagnosis with type 1 diabetes were excluded. We did not exclude respondents who indicated a diagnosis of type 2 diabetes.

6.3.4 Assessment of Breastfeeding Beliefs, Attitudes and Perceptions

The prenatal questionnaire included items that assessed the respondent's beliefs about the value of breastfeeding, and perceptions of the opinions of family and medical professionals about infant feeding. Respondents indicated their opinion of "the best way to feed a baby" by checking one of the following options: "breastfeeding," "a mix of both breast and formula feeding," formula feeding," or "breastfeeding and formula feeding are equally good ways to feed a baby." A 5-point scale was used to indicate level of agreement with each of the following statements: "Infant formula is as good as breast milk," "If a baby is breastfed, he or she will be less likely to get ear infections," "If a baby is breastfed he or she will be less likely to become obese," and

"Babies should be exclusively breastfed (fed only breast milk) for the first 6 months." For each of these variables, we collapsed responses into 2 categories: "somewhat or strongly agree" and "neutral, somewhat disagree, or strongly disagree."

Respondents were then asked to respond to "How do the following people think your baby should be fed in the first few weeks?" for the baby's father, the respondent's mother, the respondent's mother-in-law, respondent's obstetrician or other doctor, and the baby's pediatrician or other doctor. Responses were "only breastfed," "only formula fed," "both breast and formula fed," "no opinion or don't know," and "no one in this category." For analyses of these variables, we set the latter value to missing. Finally, we considered the number of respondent's friends and relatives who had breastfed their children. Response choices for this question included "one or two," "three to five," "more than five," "none have breastfed," "none have children," and "don't know." We collapsed the last two categories.

6.3.5 Assessment of Breastfeeding Intentions

Breastfeeding intentions were determined by participant responses to the question "What method do you plan to use to feed your new baby in the first few weeks?," which was part of the prenatal questionnaire. Response options were: "breastfeed only (baby will not be given formula)", "formula feed only," "both breast and formula feed," and "don't know yet." From this variable we created two dichotomous variables for intent to breastfeed at all (coded "yes" if breastfeed only or both breast and formula feed were checked) and intent to exclusively breastfeed (coded "yes" if breastfed only was checked). All other responses were coded "no" for these variables. Finally, for women who indicated an intention to breastfeed, a 5-point Likert-type scale was used to assess the respondent's confidence in her ability to breastfeed as long as planned.

6.3.6 Assessment of Neonatal Factors and Hospital Experiences Related to Breastfeeding

We used several items from the first postnatal questionnaire to assess neonatal factors and hospital experiences that could affect breastfeeding. These included how long after delivery the mother breastfed or tried to breastfeed for the first time (< 30 minutes, 30 to 60 minutes, 1 to 2 hours, 3 to 6 hours, 7 to 12 hours, or 13 to 24 hours), whether anyone helped the mother with breastfeeding in the hospital (yes or no), how many hours after the baby's birth the mother first got help with breastfeeding (< 30 minutes, 30 to 60 minutes, 1 to 2 hours, 3 to 6 hours, 7 to 12 hours, or 13 to 24 hours), whether the baby stayed in the mother's room in the hospital "except for doctor visits, bathing, or other treatments" (yes, all the time; yes, some nights but not all; or no). We further collapsed the latter variable into two levels: yes, all the time vs. any other response. Respondents were asked separately whether the baby was given sugar water, formula, or a pacifier while in the hospital (yes, no, or don't know). Time until milk came in (1 day, 2 days, 3 days, 4 days, or more than 4 days) and problems experienced with breastfeeding in the first 2 weeks were also assessed. Respondents indicated these using a checklist that included 17 possible problems (See Appendix B, Question 36).

6.3.7 Assessment of Maternal BMI and Gestational Weight Gain

Maternal pre-pregnancy BMI has been calculated from height and weight reported by respondents in the prenatal questionnaire. We further categorized maternal BMI according to standard definitions for underweight (<18.5 kg/m^2), normal weight (18.5-<25 kg/m^2), overweight (25-<30 kg/m^2), and obese (≥ 30 kg/m^2).

The neonatal questionnaire asked respondents to indicate the amount of weight they gained during pregnancy in pounds. This value was used to represent gestational weight gain, which was then categorized into quartiles.

6.3.8 Assessment of Other Variables

Other variables that were assessed as covariates included the following maternal factors: age at delivery, education level, household income as percent of poverty level, parity, smoking status during pregnancy, employment status, marital status, and race/ethnicity, type of delivery, and medication use during labor and delivery; and the following infant factors: sex, gestational age at delivery, birth weight, neonatal intensive care unit (NICU) stay, and age at introduction of solid foods.

Mother's age in years and parity (number of previous children) were obtained from the prenatal questionnaire, whereas other demographic variables were obtained from the consumer opinion panel database. If demographic information was available in the panel database for another member of the respondent's household only, the respondent was sent a short demographic questionnaire. Maternal smoking status during pregnancy was also determined by responses to the question "on the average, how many cigarettes do you smoke a day now?" Any response greater than 0 was coded as "yes" for the dichotomous smoking status variable.

Maternal age at delivery was grouped into the following categories: 18-24, 25-29, 30-34, and ≥ 35. Attained education was categorized into three levels: high school or less, some college, college graduate. Other maternal characteristics included household income as percent of the federal poverty level (<185%, 185-349%, or ≥ 350%), parity (primiparous or multiparous), smoking status during pregnancy (any smoking or no smoking), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, or other), marital status (currently married nor not married), and employment status (full-time, self-employed or part-time, or not employed). Weeks of maternity leave (continuous) was available but not included in our analyses because a value was available for only 48% of the entire prenatal sample (2,356 of 4,902 respondents). The

majority of the missingness (94.0%) was due to respondents correctly skipping the question about maternity leave because they were not employed at the time. Type of delivery (vaginal, not induced; vaginal, induced; unplanned Cesarean section; or planned Cesarean section) and medication use during labor or delivery (spinal or epidural, Demerol or Stadol, nitrous oxide, pudendal block, other pain medication, or no pain medication) was assessed in the postnatal questionnaire. We then dichotomized medication use (any medication or no medication).

Gestational age at birth in weeks was determined from infant's birth date, reported in phone screener, and the due date indicated in the prenatal questionnaire. We categorized gestational age into three levels (≥ 39 weeks, 37-38 weeks, or <37 weeks). Infant sex and birth weight were reported by the mother in a phone screener after delivery. Birth weight category was determined using Olsen et al.'s intrauterine growth curves.[126] Birth weight for gestational age and gender at < 10^{th} percentile was considered small-for-gestational-age (SGA), while birth weight > 90^{th} percentile was considered large-for-gestational age (LGA). All other birth weights were considered appropriate-for-gestational age (AGA). Age at introduction of solid foods, in weeks, was determined by the age of the infant when the mother first indicated giving solid foods in any of the postnatal questionnaires. We categorized this variable as <17 weeks (approximately 4 months), 17-25 weeks (approximately 4-6 months) or ≥ 26 weeks (approximately 6 months). Finally, participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) was assessed by prenatal and postnatal questionnaires and dichotomized (mother or child ever enrolled or neither mother nor child ever enrolled).

6.4 Statistical Analysis

The distribution of variables were assessed by frequencies or means and standard deviations. Levels of categorical variables with small numbers were collapsed, as appropriate.

For each research question, bivariate analyses were carried out for each predictor or covariate and the outcome variable. Chi square tests were used for categorical variables and Wilcoxon rank-sum tests were used for continuous variables, because none were normally distributed.

Univariate and multivariate logistic regression models were built for most outcomes, with the exception of those that were not significantly associated with predictors in bivariate tests of association ($P > .10$). For each outcome, we included all variables identified as potential confounders in an initial model and used stepwise removal of non-significant covariates to produce a more parsimonious model. Maternal age, race, and BMI were retained in multivariable models regardless of significance. The criteria for significance were a likelihood ratio test *P* value of $\leq .10$ or a change in the estimated coefficient for the primary predictor of interest of 10% or more when the covariate is removed.

Multinomial logistic regression was used to estimate associations between GDM and categorical outcomes related to the mother's perceptions of others' opinions about how the infant should be fed (breastfed only, formula fed only, breastfed and formula fed, or no opinion/not sure). "Breastfed only" was the base outcome to which all other responses were compared.

The adequacy of logistic regression models was assessed in several ways. The Hosmer-Lemeshow test was used to assess overall fit. Stata version 11.0 was used for all analyses (Stata Corporation, College Station, TX). Two-tailed *P* values of $< .05$ were considered statistically significant.

Power analyses were undertaken for all primary aims using the PASS program. We set the type I error rate at 0.05 for all analyses. For the first study, we had 98% power to detect an odds ratio for rapid weight gain of 2.08 in the group with the shortest duration of exclusive breastfeeding (no EBF) as compared to the group with the longest duration ($\geq$ 4 months) and

100% power to detect an odds ratio of 2.82 in the group with the lowest breastfeeding intensity (no breastfeeding) as compared with the highest intensity (100% milk feeds from breast milk in the first 6 months). The ORs used to calculate power were generated based on the actual distribution of the exposure and outcome variables in our samples. For the second study, we had 70% power to detect an OR of 0.64 for ever exclusively breastfeeding in GDM as compared to NDM women. Investigations of relationships between gestational diabetes and breastfeeding intentions and initiation of any breastfeeding were considered exploratory.

For the third study, we calculated power for the prenatal and postnatal analyses using a range of assumptions regarding the distribution of the predictor variable in the comparison group (nondiabetic women) and the odds ratio for the test group (women with GDM). We found that we had at least 80% power to detect odds ratios of at least 0.75 or 1.25 under nearly all circumstances. Power was reduced to 75% for an OR of 1.25 in the postnatal sample only when the probability of the outcome occurring was very high (90%) in the comparison group.

6.5 Ethical Considerations and Human Subjects Protection

The IFPS II and all questionnaires sent to participants were approved by the FDA's Research Involving Human Subjects Committee. For the purpose of the proposed secondary analysis, we were granted an exemption from the University of Massachusetts Institutional Review Board.

CHAPTER 7

NOT BREASTFEEDING OR MIXED FEEDING IS ASSOCIATED WITH RAPID WEIGHT GAIN IN INFANCY

7.1 Introduction

The long-term effects of excess weight gain in infancy remain uncertain. However, emerging evidence suggests that greater weight and more rapid rate of weight gain during the first one or two years of life are associated with increased risk of obesity in later childhood[69-71] and adiposity[8,72] and adverse metabolic risk profile[8] in adulthood. If the trajectory to obesity begins as early as infancy, as some studies suggest, it would be critical to identify early life nutritional factors that may modify that risk.

Current evidence suggests that breastfeeding may be associated with lower risk of obesity in childhood[36,71,74-77] and adulthood.[36,77] It has been hypothesized that breastfeeding may alter obesity risk by influencing the rate of weight gain during the first year of life.[78] A number of prospective cohort studies have investigated the relationship between infant milk feeding (i.e. breastfeeding or formula feeding) and the rate of gain in weight, adiposity, or other measures of growth during the first year of life, and in some cases into early childhood.[10-16,79,80] The results of these studies are relatively consistent, with most finding some association between breastfeeding and reduced infant weight gain. However, most have involved cohorts outside the U.S. and may not be generalizable to the American population.

Early, frequent, and rigorous assessment of infant feeding practices is needed to reduce the threat of recall bias and misclassification, but such precision is rare in the existing literature. As a result, many studies have utilized broad categories to define feeding practices, failing to distinguish between mixed feeding of human and nonhuman milks and either exclusive breastfeeding or exclusive formula feeding[12,14,80,127,128] Very few have investigated breastfeeding

intensity[15] or duration of exclusive breastfeeding[10] as predictors of infant weight gain in a manner that allows for dose-response analysis.

The U.S. Infant Feeding Practices Study II (IFPS II) measured infant feeding variables early, frequently, and with high precision (e.g. number of feedings per day over 7 days).[124] Two studies by Li and colleagues employed the IFPS II cohort to investigate the relationship between breastfeeding and excess weight and linear weight gain (in grams per month) in infancy, respectively.[15,16] However, neither study assessed likelihood of rapid weight gain, as defined in prior literature, and neither used the World Health Organization (WHO) growth charts to define excess weight or weight gain. It is currently recommended that the World Health Organization growth charts be used to assess weight in infants and toddlers under the age of 2 years because they represent normal growth in breastfed infants.[17]

The purpose of this study was to expand on previous research on breastfeeding and infant weight gain in the U.S. IFPS II cohort to determine whether breastfeeding intensity and exclusive breastfeeding duration are associated with the likelihood of rapid weight gain, defined as a change in weight-for-age *z*-score of >0.67 from birth to 12 months, using WHO growth standards.

7.2 Methods

7.2.1 Sample

Data from the Infant Feeding Practices Study II cohort were used to carry out this study. The IFPS II was conducted jointly by the U.S. Food and Drug Administration and the Centers for Disease Control and Prevention (CDC). The longitudinal study followed mother-infant dyads from late pregnancy to the infant's first birthday. Data were collected between May 2005 and June 2007 using a series of mailed questionnaires—one administered prenatally and 10 at

approximately monthly intervals after the infant's birth. Women who indicated being in their third trimester of pregnancy were eligible to be included. Exclusion criteria included multiple gestation, gestational age at birth less than 35 weeks, birth weight less than 5 lbs, and stay in intensive care >3 days. Additionally, mother-infant pairs were excluded if the infant had a medical condition that would affect feeding. Details of study's methodology have been published elsewhere.[124] Approximately 4,900 pregnant women enrolled in the study and ~2000 completed the final questionnaire. The sample was drawn from a consumer opinion panel of >500,000 U.S. households. The final sample for this study included 1,225 mother-infant pairs with complete data for rapid weight gain from birth to 12 months, breastfeeding intensity in the first 6 months, exclusive breastfeeding duration, and all covariates of interest

7.2.2 Outcome Measures

Infant weights were reported by mothers at the birth screener (birth weight) and at months 3, 5, 7, and 12. Respondents reported the infant's weight when measured at the last doctor's visit and the infant's age at the time of that visit. Weight-for-age *z*-scores were calculated from these two values at each time point using the WHO anthro macro for Stata (http://www.who.int/childgrowth/software/en/). Any single weight-for-age *z*-score (WAZ) that was <5 or >5 were recoded to missing, in accordance with previous research.[15] Change in WAZ from birth to 12 months was calculated by subtracting the WAZ at birth from WAZ at 12 months. WAZ change scores of >0.67 were coded "1" for rapid weight gain; all other non-missing values were coded "0."

7.2.3 Exposures

Infant feeding, including breastfeeding and use of formula and other nonhuman milks, was assessed by every postnatal questionnaire. The neonatal questionnaire included questions

about whether the mother ever attempted to breastfeed her infant; whether the infant was given any water, formula, or sugar water in the hospital; and the feeding method at discharge (breastfeeding only, formula only, or breastfeeding and formula). Exclusive breastfeeding at hospital discharge was defined on the basis of these questions. Both the neonatal questionnaire and each subsequent postnatal questionnaire measured breastfeeding and other feeding behaviors with a food frequency chart. Respondents were asked to indicate the number of feedings given per day or per week for each of several categories of milk (breast milk, formula, cow's milk, or other milk) and other foods and beverages.

An infant was considered exclusively breastfed during the hospital stay if the infant received breast milk and no water, sugar water, or formula. For each of the postnatal questionnaires, the food frequency checklist was used to define exclusive breastfeeding. Infants who received breast milk but no other foods were considered to be exclusively breastfed. Duration of exclusive breastfeeding, in weeks, was estimated as the midpoint of the infant age between the last questionnaire when exclusive breastfeeding was indicated and the questionnaire when the infant was no longer exclusively breastfed. The variable was cumulative across questionnaires; in order to be considered exclusively breastfed at any time point, the infant must have been exclusively breastfed at every prior time point. If a respondent indicated exclusively breastfeeding at multiple time points, but did not have a value for an intervening time point, it was assumed that the respondent was exclusively breastfeeding during that time point as well. We used EBF duration of ≥ 4 months as the referent group, because EBF durations of 6 months were uncommon. We kept "no exclusive breastfeeding" as a separate group, and used the median of the remaining observations (4.23 weeks, or approximately 1 month) to define two intervening groups (>0 weeks to <1 month and 1 month to < 4 months).

Breastfeeding intensity was operationalized as the percent of milk feeds that were breast milk at each time point, calculated as follows: (number of breast milk feedings / [breast milk + formula + cow's milk + other milks]) X 100%. The mean breastfeeding intensity for the first 6 months of life was calculated for infants with at least 4 non-missing values for breastfeeding intensity and at least one value for months 5 and 6. Breastfeeding intensity for the first half of infancy was then categorized into 4 levels: 1) no breast milk feeds, 2) mixed feeding with >50% of milk feeds from breast milk, 2) mixed feeding with ≤ 50% of milk feeds from breast milk, and 4) 100% breast milk feeds. We chose to categorize breastfeeding intensity in this way because the continuous variable was not linear in the logit and smoothed scatter plots revealed a change in the relationship between breastfeeding intensity and rapid weight gain at approximately 50% breast milk. Additionally, we contend that infants receiving 100% of their milk feeds from breast milk for the first 6 months of life—in accordance with current recommendations—comprise the most appropriate referent group.

7.2.4 Other Measures

Other variables that were assessed as potential confounders included the following maternal factors: age at delivery (18-24, 25-29, 30-34, or ≥ 35), education level (high school or less, some college, college graduate), household income as percent of poverty level (<185%, 185-349%, or ≥ 350%), parity (primiparous or multiparous), smoking status during pregnancy (any smoking or no smoking), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, or other), marital status (currently married nor not married), and employment status (full-time, self-employed or part-time, or not employed). Maternal pre-pregnancy BMI (kg/m^2) was calculated based on self-reported weight and height and was then categorized (<18.5, underweight; 18.5-<25.0, normal weight; 25.0-<30.0, overweight; or ≥ 30.0, obese). We grouped

gestational weight gain (lbs) into quartiles. Infant factors included sex, gestational age at delivery (≥ 39 weeks, 37-38 weeks, or <37 weeks), birth weight (kg), type of delivery (vaginal, not induced; vaginal, induced; unplanned Cesarean section; or planned Cesarean section), whether the infant required a stay in the NICU (yes/no), and age at introduction of solid foods (<17 weeks, 17-<26 weeks, or ≥ 26 weeks. Infant birth weight was obtained from the phone screener after delivery. Finally, participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) was assessed by prenatal and postnatal questionnaires and dichotomized (mother or child ever enrolled or neither mother nor child ever enrolled).

7.2.5 Statistical Analysis

Descriptive statistics were calculated for the overall sample using frequency distributions for categorical variables and means and standard deviations for continuous variables. Bivariate analyses were carried out for each predictor or covariate and rapid weight gain using Wilcoxon rank sum tests and χ^2 tests, as appropriate. All variables that were significantly associated with both the primary predictor (either breastfeeding intensity or exclusive breastfeeding duration) and the outcome were entered into initial multivariable logistic regression models. We first built separate models for EBF duration and breastfeeding intensity to determine the magnitude of association between each exposure and rapid weight gain. We retained maternal age, race, and BMI and the models regardless of significance and employed stepwise removal of other covariates to achieve more parsimonious models. The criterion for significance was a likelihood ratio test *P* value of < 0.10 or a change in the estimated coefficient for the primary predictor of interest of 10% or more when the covariate was removed. Finally, we entered EBF duration and breastfeeding intensity into the multivariable model simultaneously, to determine which variable is more strongly associated with rapid weight gain. The overall fit of logistic regression models

was assessed using the Hosmer-Lemeshow test. Stata version 11.0 was used for all analyses (Stata Corporation, College Station, TX), and two-tailed *P* values of < .05 were considered statistically significant.

Finally, to determine the extent to which our final sample resembled the initial IFPS II cohort of mothers and infants who qualified for the study after the infant's birth but were not included in our study because of missing data, we compared these groups on several key characteristics. To evaluate the impact of selection bias on our results, we carried out a sensitivity analysis using inverse-probability-weighted logistic regression.[136] The weights were the inverse of the probability of inclusion in the final multivariable models of initiation of any/exclusive breastfeeding given covariates associated with inclusion based on logistic regression models using the criterion *P* <.10.

7.3 Results

The majority of mothers in this sample were White (89.0%), multiparous (71.7%), and nonsmokers (93.3%). Most (66.1%) were between the ages of 25 and 34 and had received education beyond high school (83.3%). Over half of mothers were overweight or obese prior to pregnancy. With regard to milk feeding, approximately 87% initiated some breastfeeding, but more than half (54%) did not breastfed exclusively for any length of time. Table 2.1 includes baseline characteristics for the infants with normal weight gain and rapid weight gain, respectively. Overall, 27.7% of infants experienced rapid weight gain. In bivariate analyses, shorter duration of exclusive breastfeeding and lower intensity of breastfeeding in the first 6 months of life were both associated with rapid weight gain (*P* < .001).

Table 2.2 shows the unadjusted and adjusted odds ratios for rapid weight gain according to duration of exclusive breastfeeding and breastfeeding intensity. Compared to infants who were

exclusively breastfed for at least 4 months, shorter durations of EBF were all associated with significantly increased odds of rapid weight gain in unadjusted analyses ($P < .001$). After adjustment for maternal age, race, BMI, education, and income; and infant sex, gestational age, birth weight, and age at introduction of solid foods, odds ratios for no exclusive breastfeeding and EBF duration of < 1 month were 1.92 (95% CI, 1.19-3.09) and 2.29 (95% CI, 1.26-4.15), respectively, compared to EBF duration of >4 months. EBF duration of 1 month-<4 months was not significantly associated with rapid weight gain in the multivariable model (adjusted OR, 1.62; 95% CI, 0.91-2.90). A linear trend between EBF duration and rapid weight gain was evident and statistically significant (P =.01).

To determine whether the association between exclusive breastfeeding duration and rapid weight gain was affected by short-term supplementation in the hospital that was subsequently followed by exclusive breastfeeding, we repeated the analyses including only infants who were exclusively breastfed at hospital discharge (N=804), and the estimates were virtually unchanged. Adjusted ORs were 1.74 (95% CI, 0.95-3.16) for EBF 1 month- <4 months, 2.29 (95% CI, 1.26-4.15) for <1 month, and 1.92 (1.19-3.09) for no EBF.

Odds ratios for rapid weight gain by breastfeeding intensity are also shown in Table 2.2. Adjusting for the same factors listed above, any level of mixed feeding was associated with increased likelihood of rapid weight gain. Compared with 100% breast milk feeds, milk feeding comprised of 50-99% breast milk was associated with an adjusted OR of 1.93 (95% CI, 1.25-2.99). The adjusted ORs for breastfeeding intensities of 1-49% breast milk or no breast milk were 2.92 (95% CI, 1.80-4.74) and 2.81 (95% CI, 1.75-4.49), respectively (P for trend <.001). Additional adjustment for parity, gestational weight gain, maternal smoking, marital status, and employment status did not substantially alter the results for either model. In a mutually-adjusted

model, EBF duration was no longer associated with rapid weight gain, while breastfeeding intensity remained similarly associated.

Because the final sample was considerably smaller than the initial IFPS II sample, we compared key characteristics of mother-infant pairs who were included in our analyses and those who qualified for the study but had missing data for weight gain over the first year of life (Table 2.3). Several significant differences between the groups were identified. The sample for this study was more likely to have ever breastfed and to have a larger infant. Compared with those who were not included in the final sample, mothers included were older, had higher incomes, were more likely to be White, and more likely to have graduated from college. Our sample had slightly greater percentages of women who were overweight or obese prior to pregnancy, though this difference was not statistically significant (P=.07). Other differences that were non-significant by a small margin included longer maternity leaves (P=.06) and fewer full-time workers (P=.07). There were no significant differences between the groups in infant sex, mean birth weight, or gestational age at birth; and no differences in maternal parity or gestational weight gain. The results of inverse-probability-weighted models are presented in Table 2.4. They were not substantially different from the unweighted estimates. The Hosmer-Lemeshow test indicated there was no significant lack of fit in any of our models.

7.4 Discussion

We observed an approximately two- to three-fold increase in risk of rapid weight gain among infants with lower intensities of breast milk feeding or shorter durations of exclusive breastfeeding. Breastfeeding intensity in particular appears to be driving this association, as the relationship between exclusive breastfeeding duration and rapid weight gain disappeared when both measures were included in the same model. This may be because duration of exclusive

breastfeeding is contingent upon complete avoidance of formula and other foods at all times. Infants who received formula in the hospital or briefly at other times but were otherwise exclusively breastfed were nevertheless considered to have an exclusive breastfeeding duration of zero. It may be that short-term supplementation is not as important to an infant's weight gain trajectory as the long-term ratio of breast milk to formula feedings. Although the association persisted when we restricted analyses to infants who were exclusively breastfed at hospital discharge, suggesting that supplementation in the hospital did not influence our findings, we could not account for the effect of short-term supplementation after leaving the hospital. We suggest that the percent of milk feeds that are breast milk in early infancy (0-6 months) may be preferable to EBF duration as a breastfeeding outcome and as measure of breastfeeding exposure.

Our findings are largely consistent with previous literature.[10-16,79,80] Furthermore, we observed what we consider a threshold effect of both breastfeeding intensity and duration of exclusive breastfeeding. Exclusive breastfeeding for less than 4 months and any amount of mixed feeding in the first 6 months of life increased rapid weight gain significantly In this sample, infants who were fed any amount of nonhuman milk during the first 6 months of life were more likely to gain weight rapidly.

Li and colleagues previously investigated the association between breastfeeding intensity in early infancy and excess weight in late infancy using the IFPS II cohort.[15] They defined breastfeeding intensity, as we did, by percent of milk feeds that were breast milk in the first 6 months of the infant's life. This variable was categorized differently, however, into 3 levels: <20%, 20-80%, and >80% breast milk. Li et al. found that, compared to high-intensity breastfeeding (>80%), the adjusted ORs for excess weight were 2.11 (95% CI, 1.24-3.60) and

2.32 (95% CI, 1.40-3.84), respectively, for medium and low-intensity breastfeeding. We found similar associations between breastfeeding intensity and rapid weight gain, though the odds ratios for mixed feeding < 50% breast milk and no breast milk were slightly higher than those reported by Li et al. for excess weight. The difference may be attributable to our using a more sensitive outcome measure or using infants who received 100% breast milk as the referent group.

Our findings with regard to exclusive breastfeeding duration are also consistent with those of a 2005 study by Kalies et al.,[10] which measured associations between exclusive breastfeeding duration and odds of elevated weight gain at 24 months, defined as weight gain > 90th percentile, in a German cohort of 2377 infants. Compared with EBF duration of ≥ 6 months, shorter durations of breastfeeding were associated with greater odds of elevated weight gain, with a significant dose-response trend (P <.001). The adjusted ORs for 0-1 months, 2-3 months, and 4-5 months were 1.99 [95% CI, 1.34-2.97], 1.61 [95% CI, 1.04-2.50], and 1.40 [95% CI, 0.93-2.11], respectively. The magnitude of the associations reported by Kalies et al. is similar to that reported in the present study.

Although there were significant linear trends for increasing odds or rapid weight gain with shorter durations of EBF and lower breastfeeding intensity, the magnitude of association between reduced breastfeeding intensity or EBF duration and rapid weight gain was not radically different at each level, suggesting a kind of threshold effect. It may be that long-term intense breastfeeding with little or no supplementation is necessary to avoid increased risk of rapid weight gain. Our findings support the current American Academy of Pediatrics (AAP) recommendation that infants be exclusively breastfed for 6 months,[2] and highlight the need for education and support for breastfeeding mothers in attaining that goal.

Numerous explanations for a protective effect of breastfeeding on infant weight gain have been proposed. Nutritional differences between formula and breast milk may contribute to slower weight gain in breastfed infants; formula is typically significantly higher in protein compared to breast milk[129] and lacks other bioactive compounds found in breast milk such as adipocytokines and appetite-regulating hormones.[130] Additionally, at-the-breast feeding might better promote self-regulation of intake by the infant.[131-133] On the other hand, women who choose to breastfeed may have an overall approach to feeding that is less controlling and more supportive of the development of healthy eating habits.[134] They may also differ in other characteristics that we did not control for; therefore, the possibility of residual confounding cannot be eliminated.

Our results should be interpreted in the context of several limitations. Infant weight measures and all other variables were self-reported by mothers. Because of concerns about the validity of infant length data, as reported by Li et al.,[15] we were unable to assess change in infant weight-for-length *z*-scores, which may be a stronger predictor of long-term obesity risk.[72] Additionally, the WHO has published infant weight velocity standards, which could be used to determine whether infant weight gain is excessive.[135] However, these standards are for growth during defined age intervals that did not correspond to the ages for which we had weight data for our sample. Therefore, we chose to use change in weight-for-age *z*-score >0.67 at 12 months to define rapid weight gain. We contend that this definition is preferable as a measure of obesity risk compared with any static weight measure or unstandardized absolute weight gain. Furthermore, it is a strength that we used WHO growth standards as opposed to CDC growth reference values to define rapid weight gain, as is recommended for infants and children under age 2 years.[17]

It should also be noted that our sample was not selected randomly from the U.S. population and consisted of women who were motivated to complete multiple lengthy questionnaires. Such women likely differ in important ways from other women. Compared to a random sample of U.S. mothers of infants born in 1998-2000, mothers participating in IFPS II were older, more highly educated, less likely to have low income, less likely to smoke during pregnancy, and more likely to be white.[124] The IFPS II participants were also more likely to be employed and reported longer maternity leaves. To minimize the effect that these variables had on our measures of association between breastfeeding and infant weight gain, we assessed all as possible confounders and included any that were significant in our final models. Length of maternity leave was not associated with either breastfeeding practices or rapid weight gain (data not shown). Although employment and marital status were associated with both the exposure and outcome, these were no longer significant when included in multivariable models. Additionally, our analyses were limited to mother-infant pairs with complete data for breastfeeding practices and infant weight at birth and 12 months. There were several differences between participants who completed the study (i.e. through the infant's first year of life) and those who completed the first postnatal questionnaire. We repeated our analyses using inverse probability weighting to reduce the impact that any selection bias may have had on our results, and these findings were not considerably different from the unweighted estimates, suggesting that the exclusion of participants with missing data for the variables of interest did not introduce significant bias into the study.

Despite these limitations, our study also has some strengths over previous studies of breastfeeding and infant weight gain. The IFPS II was designed with assessment of infant feeding as a primary goal.[124] As a result, infant feeding practices were assessed approximately

monthly and in great detail, allowing for measurement of breastfeeding intensity and exclusivity and reducing the likelihood of severe misclassification of the exposure. The prospective design of the study also minimizes the risk of recall bias.

7.5 Conclusions

In summary, our findings indicate that lower breastfeeding intensity in early infancy is associated with an approximately two-to-threefold increase in odds of rapid weight gain by 12 months of age. Because rapid infant weight gain is strongly associated with risk of obesity and cardiometabolic risk factors in later life, these findings support the hypothesis that breastfeeding may protect against obesity in part by limiting weight gain in infancy. Importantly, any amount of mixed feeding was associated with rapid weight gain in this sample, even when infants were receiving more than 50% of their milk feeds from breast milk. Although most women in this sample did initiate breastfeeding, the vast majority did not reach current guidelines for exclusive breastfeeding. The results of this study underline the potential importance of encouraging and providing support for sustained exclusive breastfeeding among new mothers.

Table 2.1. Sample characteristics by infant weight gain category (*N*=1,225)

Characteristic	Normal Weight Gain (*n*=886) *n* (%)	Rapid Weight Gain (*n*=339) *n* (%)	*P*
Primiparous (*N*=1,213)	234 (26.6)	109 (32.8)	.03
Maternal pre-pregnancy BMI (kg/m^2)			.07
<18.5	27 (3.1)	17 (5.0)	
18.5-<25	410 (46.3)	132 (38.9)	
25-<30	225 (25.4)	98 (28.9)	
≥ 30	224 (25.3)	92 (27.1)	
Mother's race/ethnicity			.05
Non-Hispanic White	794 (89.6)	296 (87.3)	
Non-Hispanic Black	15 (1.7)	14 (4.1)	
Hispanic	40 (4.5)	19 (5.6)	
Other	37 (4.2)	10 (3.0)	
Mother's education			<.001
HS or less	124 (14.0)	80 (23.6)	
Some college	303 (34.2)	115 (33.9)	
College graduate or more	459 (51.8)	144 (42.5)	
Maternal age			.01
18-24	98 (11.1)	59 (17.4)	
25-29	301 (34.0)	104 (30.7)	
30-34	304 (34.3)	100 (29.5)	
≥ 35	183 (20.7)	75 (22.4)	
Income as % of poverty level			.13
<185	298 (33.6)	121 (35.7)	
185-349	344 (38.8)	111 (32.7)	
≥ 350	244 (27.5)	107 (31.6)	
Mother smoked during pregnancy (*N*=1,222)	45 (5.2)	36 (10.7)	.001
Mother was not married (*N*=1,218)	120 (13.6)	65 (19.3)	.01
Mother or infant enrolled in WIC	227 (25.7)	112 (33.0)	.01
Mother's employment status (*N*=1,144)			.26
Employed full-time	307 (37.0)	132 (42.0)	
Self-employed or part-time	164 (19.8)	61 (19.4)	
Not employed	359 (43.3)	121 (38.5)	
Gestational weight gain (*N*=1,192)			<.01
Q1 <23 lbs	201 (23.4)	99 (29.7)	
Q2 23-<30 lbs	138 (16.1)	72 (21.6)	
Q3 30-<40 lbs	271 (31.6)	93 (27.9)	
Q4 ≥ 40 lbs	249 (29.0)	69 (20.7)	
Infant sex, female	470 (53.1)	164 (48.4)	.14
Birth weight, kg, mean (SD)	3.60 (0.44)	3.14 (0.39)	<.001
Gestational age at birth			<.001
≥ 39 weeks	629 (71.0)	156 (46.0)	

37-38 weeks	241 (27.2)	147 (43.4)	
35-36 weeks	16 (1.8)	36 (10.6)	
Infant stayed in the NICU	21 (2.4)	10 (3.0)	.56
Type of delivery			.31
Vaginal, not induced	345 (39.0)	121 (35.7)	
Vaginal, induced	282 (31.9)	115 (33.9)	
Planned C-section	168 (19.0)	58 (17.1)	
Unplanned C-section	90 (10.2)	45 (13.3)	
Exclusive breastfeeding duration			<.001
≥ 17 weeks	226 (25.5)	36 (10.3)	
4.23-<17 weeks	116 (13.1)	46 (13.6)	
1-<4.23 weeks	95 (10.7)	49 (14.5)	
None	449 (50.7)	209 (61.7)	
Breastfeeding intensity			<.001
100%	304 (34.3)	52 (15.3)	
50-99%	262 (29.6)	92 (27.1)	
1-49%	142 (16.0)	80 (23.6)	
0%	178 (20.1)	115 (33.9)	
Age at introduction of solid foods, mean (SD)	20.82 (5.83)	19.17 (5.20)	<.001

P values were obtained by Wilcoxon rank sum test for continuous variables and X^2 tests for categorical variables

Table 2.2. Unadjusted and multivariable-adjusted odds ratios for breastfeeding practices and rapid weight gain (*N*=1,225)

	Unadjusted		Fully Adjusted[a]		Mutually Adjusted[b]	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
EBF duration						
≥ 17 weeks	1.0		1.0		1.0	
4.23- <17 weeks	2.56 (1.56-4.19)	<0.001	1.62 (0.91-2.90)	.10	1.17 (0.62-2.20)	.62
1-<4.23 weeks	3.33 (2.03-5.47)	<0.001	2.29 (1.26-4.15)	<.01	1.22 (0.61-2.44)	.58
None	3.00 (2.03-4.45)	<0.001	1.92 (1.19-3.09)	<.01	1.03 (0.58-1.85)	.91
Breastfeeding intensity as % of milk feeds						
100%	1.0		1.0		1.0	
50-99%	2.05 (1.41-3.00)	<.001	1.93 (1.25-2.99)	<.01	1.84 (1.12-3.02)	.02
1-49%	3.29 (2.20-4.92)	<.001	2.92 (1.80-4.74)	<.001	2.81 (1.59-4.96)	<.001
0%	3.78 (2.59-5.50)	<.001	2.81 (1.76-4.49)	<.001	2.81 (1.59-4.94)	<.001

a Adjusted for maternal age, race, BMI, education, and income; and infant sex, birth weight, gestational age, and age at introduction of solid foods
b Each breastfeeding measure adjusted for the other and for all factors above

Table 2.3. Comparison of mother-infant pairs included and excluded because of missing data (*N*=3,033)

Characteristic	Excluded (*n*=1,808) *n* (%)	Included (*n*=1,225) *n* (%)	*P*
Primiparous (*N*=2,835)	485 (29.9)	343 (28.3)	.35
Maternal pre-pregnancy BMI (kg/m^2) (*N*=2,879)			.07
<18.5	89 (5.4)	44 (3.6)	
18.5-<25	760 (46.0)	542 (44.2)	
25-<30	414 (25.0)	323 (26.4)	
≥ 30	391 (23.6)	316 (25.8)	
Mother's race/ethnicity (*N*=2,948)			<.001
Non-Hispanic White	1,397 (81.1)	1,090 (89.0)	
Non-Hispanic Black	114 (6.6)	29 (2.4)	
Hispanic	124 (7.2)	59 (4.8)	
Other	88 (5.1)	47 (3.8)	
Mother's education (*N*=2,783)			<.001
HS or less	380 (24.4)	204 (16.7)	
Some college	702 (45.1)	418 (34.1)	
College graduate or more	476 (30.6)	603 (49.2)	
Maternal age (*N*=3,028)			<.001
18-24	546 (30.3)	157 (12.8)	
25-29	614 (34.1)	405 (33.1)	
30-34	430 (23.9)	404 (33.0)	
≥ 35	213 (11.8)	259 (21.1)	
Income as % of poverty level (*N*=2,915)			<.001
<185	811 (48.0)	419 (34.2)	
185-349	587 (34.7)	455 (37.1)	
≥ 350	292 (17.3)	351 (28.7)	
Mother smoked during pregnancy (*N*=2,904)	212 (12.6)	82 (6.7)	<.001
Mother is not married (*N*=2,801)	401 (25.3)	185 (15.2)	<.001

Mother or child enrolled in WIC (*N*=3,029)	809 (44.8)	339 (27.7)	<.001
Mother's employment status (*N*=2,578)			.001
Full-time	464 (32.4)	439 (38.4)	
Self-employed or part-time	270 (18.8)	225 (19.7)	
Not employed	700 (48.8)	480 (42.0)	
Gestational weight gain (*N*=2,800)			.24
Q1 <23 lbs	399 (24.8)	300 (25.2)	
Q2 23-<30 lbs	266 (16.5)	210 (17.6)	
Q3 30-<40 lbs	459 (28.5)	364 (30.5)	
Q4 ≥ 40 lbs	484 (30.1)	318 (26.7)	
Infant sex, female (*N*=3,030)	895 (49.6)	634 (51.8)	.24
Birth weight, kg, mean (SD) (*N*=2,915)	3.45 (0.48)	3.48 (0.47)	.02
Gestational age at birth (*N*=2,915)			.29
≥39 weeks	1,104 (65.3)	785 (64.1)	
37-38 weeks	499 (29.5)	388 (31.7)	
35-36 weeks	87 (5.2)	52 (4.2)	
Birth weight category (*N*=2,912)			<.01
AGA	1,443 (85.5)	1,051 (85.8)	
SGA	74 (4.4)	29 (2.4)	
LGA	170 (10.1)	145 (11.8)	
Type of delivery (*N*=2,908)			.01
Vaginal, not induced	637 (87.8)	466 (38.1)	
Vaginal, induced	590 (35.0)	397 (32.4)	
Planned C-section	242 (14.4)	226 (18.5)	
Unplanned C-section	215 (12.8)	135 (11.0)	
Infant stayed in the NICU (*N*=3,033)	45 (2.5)	31 (2.5)	.94
Ever breastfed	1,517 (83.9)	1,069 (87.3)	.01

P values were obtained by Wilcoxon ranks sum test for continuous variables and X^2 tests for categorical variables

Table 2.4. Results of inverse-probability-weighted logistic regression models of breastfeeding and rapid weight gain (*N*=1,132)

	Fully Adjusted[a]		Mutually Adjusted[b]	
	OR (95% CI)	*P*	OR (95% CI)	*P*
EBF duration				
≥ 17 weeks	1.0		1.0	
4.23- <17 weeks	1.51 (0.82-3.17)	.17	1.13 (0.54-2.39)	.74
1-<4.23 weeks	2.02 (1.02-3.99)	.04	1.04 (0.47-2.27)	.93
None	1.92 (1.12-3.31)	.02	1.00 (0.51-1.95)	1.00
Breastfeeding intensity as % of milk feeds				
100%	1.0		1.0	
50-99%	1.93 (1.17-3.16)	<.01	1.91 (1.08-3.38)	.03
1-49%	3.13 (1.80-5.42)	<.001	3.15 (1.64-6.03)	.001
0%	2.75 (1.63-4.62)	<.001	2.83 (1.51-5.31)	.001

a Adjusted for maternal age, race, BMI, education, and income; and infant sex, birth weight, gestational age, and age at introduction of solid foods

b Each breastfeeding measure adjusted for the other and for all factors above

CHAPTER 8

ASSOCIATIONS BETWEEN GESTATIONAL DIABETES MELLITUS AND BREASTFEEDING INTENTIONS AND PRACTICES

8.1 Introduction

Maternal gestational diabetes mellitus (GDM), which results in an elevated supply of glucose to the fetus, has the potential to influence infant metabolic programming prenatally and lead to increased risk of obesity and chronic disease in later life.[20-22] Increasing maternal glycemia during pregnancy has been positively associated with increasing risk of obesity in children at age 5-7 years.[20] Maternal GDM has also been associated with impaired glucose metabolism,[22] and children born large for gestational age to women with GDM appear to be at especially high risk.[21] Although some of these associations may be explained by genetics, it has been proposed that fetal hyperinsulinemia and hyperleptinemia, in response to increased available glucose concentrations, may induce changes in the hypothalamus and pancreas that lead to impaired appetite regulation and/or insulin secretion in the offspring.[23]

Breastfeeding has been found to have particular benefits for women with a history of GDM and their infants.[19,83-86] Several cross-sectional and cohort studies have suggested a benefit of breastfeeding for short-term insulin sensitivity and glucose homeostasis among postpartum women with[87-90] or without a history of GDM.[91] Studies have observed improved insulin sensitivity[96] or reduced risk of type 2 diabetes[95] many years postpartum in women who breastfed for longer durations. Although inconclusive, a few studies have also found a protective association between breastfeeding and type 2 diabetes risk among offspring of women with GDM.[24-26]

Despite the established benefits of breastfeeding for women and infants in general, and possible benefits for women with GDM and their children in particular, there is some evidence that breastfeeding rates may be lower among women with GDM, [98-100] though relatively little research has examined infant feeding practices in women after GDM pregnancies. Some have lacked either a prospective design or a long duration of follow-up,[98,100] thereby limiting the extent to which differences in duration of breastfeeding could be assessed. Only one, a German study by Hummel et al., measured exclusivity of breastfeeding and included a follow-up of several months.[99] To date, few prospective studies in the U.S. that have assessed breastfeeding behaviors among women with GDM or attempted to identify when and how the infant feeding behaviors of women with and without GDM diverge.

8.2 Objectives

The purpose of this study was to determine whether the following breastfeeding intentions and behaviors differed by GDM status in U.S. mother-infant dyads from the Infant Feeding Practices Study II (IFPS II) prospective cohort: intention to breastfeed at all or exclusively; initiation of any or exclusive breastfeeding; duration of any or exclusive breastfeeding; and breastfeeding intensity, defined as percent of milk feeds that were breast milk in the first half of infancy.

8.3 Methods

8.3.1 Sample

Data from the IFPS II cohort were used to carry out this study.[124] The IFPS II, conducted jointly by the U.S. Food and Drug Administration and the Centers for Disease Control and Prevention (CDC), is a longitudinal study of mother-infant dyads followed

from late pregnancy to the infant's first birthday. Data were collected between May 2005 and June 2007 using a series of mailed questionnaires: one administered prenatally and 10 at approximately monthly intervals after the infant's birth. A brief phone questionnaire was used shortly after delivery to collect basic information about the birth to confirm eligibility. Women who indicated being in their third trimester of pregnancy were eligible to be included in the study. Exclusion criteria included multiple gestation, gestational age at birth less than 35 weeks, birth weight less than 5 lbs, and stay in intensive care >3 days. Additionally, mother-infant pairs were excluded if the infant had a medical condition that would affect feeding. Details of study's methodology have been published elsewhere.[124]

Approximately 4,900 pregnant women enrolled in the study and 3,033 completed the first postnatal questionnaire. The sample was drawn from a consumer opinion panel of >500,000 U.S. households. For this study, we used data from the prenatal and neonatal questionnaires and a brief screening interview administered by phone shortly after birth. For analyses of breastfeeding intentions, our sample included 3,244 women who completed the prenatal questionnaire and had complete data for breastfeeding intentions and relevant covariates. For analyses of breastfeeding practices, our sample was comprised of 2,051 mother-infant dyads who completed a neonatal questionnaire and were not missing data for variables of interest.

8.3.2 Primary Outcome Measures

Breastfeeding intentions were determined by participant responses to the question "What method do you plan to use to feed your new baby in the first few weeks?," which was part of the prenatal questionnaire. Response options were: "breastfeed only (baby

will not be given formula)", "formula feed only," "both breast and formula feed," and "don't know yet." From this variable we created two dichotomous variables for intent to breastfeed at all (coded "yes" if breastfeed only or both breast and formula feed were checked) and intent to exclusively breastfeed (coded "yes" if breastfed only was checked). All other responses were coded "no" for these variables.

Infant feeding, including breastfeeding and use of formula and other nonhuman milks, was assessed by every postnatal questionnaire. The neonatal questionnaire, which was administered at approximately 1 month of age, included questions about whether the mother ever attempted to breastfeed her infant and the feeding method at discharge (breastfeeding only, formula only, or breastfeeding and formula). Respondents who indicated that they ever breastfed were also asked whether the infant was given any water, formula, or sugar water in the hospital. Exclusive breastfeeding at hospital discharge was defined on the basis of these questions. Both the neonatal questionnaire and each subsequent postnatal questionnaire measured breastfeeding and other feeding behaviors with a food frequency chart. Respondents were asked to indicate the number of feedings given per day or per week for each of several categories of milk (breast milk, formula, cow's milk, or other milk) and other foods and beverages.

An infant was considered exclusively breastfed during the hospital stay if the infant received breast milk and no water, sugar water, or formula. For each of the postnatal questionnaires, the food frequency checklist was used to define exclusive breastfeeding. Infants who received breast milk but no other foods or fluids were considered to be exclusively breastfed. Duration of exclusive breastfeeding, in weeks, was estimated as the midpoint of the infant age between the last questionnaire when

exclusive breastfeeding was indicated and the questionnaire when the infant was no longer exclusively breastfed. The variable was cumulative across questionnaires; in order to be considered exclusively breastfed at any time point, the infant must have been exclusively breastfed at every prior time point. If a respondent indicated exclusively breastfeeding at multiple time points, but did not have a value for an intervening time point, it was assumed that the respondent was exclusively breastfeeding during that time point as well. To capture early differences in exclusive breastfeeding (EBF), we created a dichotomous variable, "ever exclusively breastfed" (EBF duration of >0 weeks vs. 0 weeks). Breastfeeding intensity was operationalized as the percent of milk feeds that were breast milk at each time point, calculated as follows: (number of breast milk feedings / [breast milk + formula + cow's milk + other milks]) X 100%. The mean breastfeeding intensity for the first 6 months of life was calculated for infants with at least 4 non-missing values for breastfeeding intensity and at least one value for months 5 and 6.

8.3.3 Exposure

Maternal GDM was measured by a single item in the prenatal questionnaire, which was completed during the third trimester of pregnancy. The question asked respondents whether they had been diagnosed with gestational diabetes in this pregnancy. Women who indicated a diagnosis of type 1 (n=29) or type 2 diabetes (n=53) were excluded.

8.3.4 Other Measures

Maternal age at delivery was grouped into the following categories: 18-24, 25-29, 30-34, and ≥ 35. Attained education was categorized into three levels: high school or less,

some college, college graduate. Other maternal characteristics included household income as percent of the federal poverty level (<185%, 185-349%, ≥ 350%), parity (primiparous or multiparous), smoking status during pregnancy (any smoking, no smoking), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other), marital status (currently married or not married), and employment status (full-time, self-employed or part-time, not employed). Maternal pre-pregnancy BMI (kg/m^2) was calculated based on self-reported weight and height and was then categorized (<18.5, underweight; 18.5-<25.0, normal weight; 25.0-<30.0, overweight; ≥ 30.0, obese). We grouped gestational weight gain (lbs) into quartiles. Gestational age at birth in weeks was determined from infant's birth date, reported in phone screener, and the due date indicated in the prenatal questionnaire. We categorized gestational age into three levels (≥ 39 weeks, 37-38 weeks or <37 weeks). Infant sex and birth weight were reported by the mother in a phone screener after delivery. Birth weight category was determined using Olsen et al.'s intrauterine growth curves.[126] Birth weight for gestational age and gender at < 10^{th} percentile was considered small-for-gestational age (SGA), while birth weight > 90^{th} percentile was considered large-for-gestational age (LGA). All other values were considered appropriate-for-gestational-age (AGA). Type of delivery (vaginal, not induced; vaginal, induced; unplanned Cesarean section; planned Cesarean section) was assessed in the postnatal questionnaire. Finally, participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) was assessed by prenatal and postnatal questionnaires and dichotomized (mother or child ever enrolled, neither mother nor child ever enrolled).

8.3.5 Statistical Analysis

Frequency distributions and means and standard deviations were calculated to describe the overall prenatal and postnatal samples. Bivariate analyses were carried out using Wilcoxon rank sum tests and χ^2 tests, as appropriate, to determine associations between GDM status and most outcome variables and covariates. To assess differences in duration of breastfeeding and breastfeeding intensity by GDM status, Wilcoxon rank sum tests were used because these variables were not normally distributed. Multivariable logistic regression models were built to determine adjusted odds ratios for initiation of any breastfeeding and initiation of exclusive breastfeeding. All variables that were significantly associated with both GDM and the outcome were entered into initial multivariable logistic regression models. We then employed stepwise removal of non-significant covariates to achieve more parsimonious models. The criterion for significance was a likelihood ratio test *P* value of ≤ 0.10 or a change in the estimated coefficient for the primary predictor of interest of 10% or more when the covariate was removed. We retained maternal age, race/ethnicity, and BMI in the multivariable models regardless of significance.

Finally, to determine the extent to which our final sample resembled the initial IFPS II cohort of mothers and infants who qualified for the study but were not included in our study because of missing data, we compared these groups on several key characteristics. To overcome possible selection bias and reweight the models back to the source population, we used inverse probability weighted modeling.[136] The weights were the inverse of the probability of inclusion in the final multivariable models of initiation of

any/exclusive breastfeeding given covariates significantly associated with inclusion based on logistic regression models.

The overall fit of logistic regression models was assessed using the Hosmer-Lemeshow test. Stata version 11.0 was used for all analyses (Stata Corporation, College Station, TX), and two-tailed *P* values of < .05 were considered statistically significant.

8.4 Results

Women in the prenatal and postnatal samples were largely non-Hispanic White (83.4% and 85.7%, respectively), between the ages of 25 and 34 (61.5% and 70.5%), and married (77.2% and 81.1%). Most had at least some college education (76.8% and 80.2%), and the vast majority did not smoke during pregnancy (89.0% and 91.6%). Approximately 6.5% of both the prenatal and postnatal samples reported being diagnosed with GDM during the current pregnancy. Descriptive statistics for all relevant characteristics, by GDM status, are presented for the prenatal and postnatal samples in Table 3.1.Women with GDM were significantly more likely to give birth at 37-38 weeks of gestation vs. 39 weeks or later (*P* <.001), were more likely to be overweight or obese (*P* <.001), and older (*P* <.001). Women with GDM gained less weight during pregnancy (*P* <.001) and were more likely to deliver by Cesarean section (*P* =.001). Although more infants of mothers with GDM were born large-for-gestational age (LGA) (16.5% vs. 10.9%), this difference was not statistically significant (*P* =.11).

The majority of nondiabetic women (61.5%) and women with GDM (51.8%) intended to exclusively breastfeed their newborns. Slightly greater proportions of women with GDM intended to formula feed (15.4% vs. 12.7% of NDM women) or both breastfeed and formula feed (28.7% vs. 22.5% of NDM women). Few women had not

decided how to feed their baby yet (4.1% of GDM and 3.2 % of NDM women). Before adjusting for potential confounders, intentions to breastfeed at all were similar between GDM and NDM women (OR, 0.85; 95% CI, 0.60-1.21), but women with GDM significantly less likely to intend to breastfeed exclusively (OR, 0.72; 95% CI, 0.55-0.95). However, after adjusting for maternal age, pre-pregnancy BMI, race, parity, education, WIC participation, employment status, and marital status, the relationship between GDM and EBF intention was no longer significant (adjusted OR, 0.82; 95% CI, 0.61-1.09).

Among women with postnatal data, those with GDM were somewhat less likely to ever breastfeed (OR, 0.66; 95% CI, 0.42-1.03), but not significantly so (Table 3.2). Adjustment for covariates further attenuated the association (adjusted OR, 0.72; 95% CI, 0.44-1.19). However, GDM was associated with a significantly reduced likelihood of ever breastfeeding exclusively, even after adjustment for multiple potential confounders (adjusted OR, 0.64; 95% CI, 0.43-0.96). When we restricted analyses of ever EBF to women who had intended to EBF, the association with GDM was similar (adjusted OR, 0.61; 95% CI, 0.37-1.01). Infants born to mothers with GDM who initiated any breastfeeding were also more likely to be given formula in the hospital than infants born to NDM mothers (adjusted OR, 1.78; 95% CI, 1.16-2.74).

Table 3.3 presents results of Wilcoxon rank sum tests comparing duration of any and exclusive breastfeeding by GDM status. Duration of any breastfeeding was not significantly different between the groups (P = .14). Duration of exclusive breastfeeding and mean percent of milk feeds that were breast milk in the first 6 months of life were both significantly lower among women with GDM (P <.001 and P =.01, respectively).

However, when we restricted analyses to women who ever breastfed exclusively, these differences disappeared ($P > .05$).

A comparison of the postnatal sample and IFPS II participants who completed a prenatal or postnatal questionnaire but were excluded from our analyses because of missing data are presented in Tables 3.4 and 3.5, respectively. The results of inverse-probability-weighted models are presented in Table 3.6. They were largely unchanged from the unweighted estimates. The Hosmer-Lemeshow test indicated there was no significant lack of fit in any of our models.

8.5 Comment

8.5.1 Main Findings

We observed that women who had GDM during pregnancy were less likely to ever breastfeed exclusively compared with women with NDM pregnancies. Among women who ever breastfed exclusively, duration of exclusive breastfeeding was not significantly different between groups. We also observed a nearly two-fold increased odds of formula supplementation in the GDM group. Together, these findings suggest that the factors contributing to differences in exclusive breastfeeding may occur before or during the early postpartum period, rather than days or weeks later.

Rates of initiation of any breastfeeding were similar in women with GDM and NDM pregnancies. Similarly, there were no differences in intention to breastfeed among pregnant respondents with GDM compared to NDM women. However, we observed a slight tendency toward reduced intention to breastfeed exclusively. Although the difference was not statistically significant, it should be noted that analyses of

breastfeeding intentions were exploratory in nature and we did not have adequate power to detect significant differences with our sample size.

8.5.2 Strengths and Limitations

This study has a number of unique strengths. The IFPS II was designed with assessment of infant feeding as a primary goal.[124] As a result, infant feeding practices were assessed in great detail and within the first few weeks of birth. This allowed for measurement of breastfeeding exclusivity and reduced the likelihood of misclassification of the outcome. Misclassification of the exposure, GDM, is possible because diagnosis was self-reported and not confirmed by biochemical measures. However, the prospective nature of the study minimized recall bias in assessment of GDM. Because data were collected both during pregnancy and after delivery, we were able to assess differences in breastfeeding intentions and behaviors.

It should be noted that our sample was not selected randomly and therefore we cannot generalize our findings beyond this sample. The IFPS II cohort was comprised of women who were motivated to complete multiple lengthy questionnaires. Such women likely differ in important ways from other women. Compared to a random sample of U.S. mothers of infants born in 1998-2000, mothers participating in IFPS II were older, more highly educated, less likely to have low income, less likely to smoke during pregnancy, and more likely to be white.[124] IFPS II participants were also more likely to be employed and reported longer maternity leaves compared with the representative U.S. sample. Within this cohort, we also observed some significant differences between completers and non-completers for our analyses. To minimize the effect such characteristics had on our results, we controlled for these and many other possible confounders. We used

inverse probability weighted modeling to minimize the effect of any self-selection bias in our study, which did not substantially alter our results. However, further research is needed to confirm our findings in populations of differing ethnic and socioeconomic backgrounds.

We did not have data that could indicate the severity of GDM, such as whether it was treated by diet, oral medications, or insulin. Because the severity of diabetes can influence onset of lactation, this may be an important moderating factor. Finally, our null findings with regard to initiation of any breastfeeding and intentions to breastfeed should not be considered unequivocal, as we were not adequately powered to detect differences in these outcomes, which we considered to be secondary aims of the study.

8.5.3 Comparison with Existing Literature

The relatively few studies of breastfeeding practices among women with GDM in the literature have generally observed reduced breastfeeding rates in this group.[98,99] Hummel and colleagues compared breastfeeding practices of German postpartum women with or without GDM (*n*=257 and *n*=527, respectively) who enrolled in the BABYDIAB study between 1989 and 2000.[99] In contrast to our findings, they found that initiation of any breastfeeding was lower in the GDM group (75% vs. 86%, *P* <.001). Further, among those who initiated breastfeeding, median duration of full breastfeeding (defined as giving no foods or drinks other than breast milk, water, or teas) was lower for GDM vs. NDM (9 vs. 17 weeks, *P* < .001), as was the median duration of any breastfeeding (16 vs. 26 weeks, *P* < .001). Our findings are more similar to those reported by Finkelstein et al., who used a retrospective design to assess breastfeeding among women with pre-gestational (insulin-treated or non-insulin-treated) and gestational diabetes who gave

birth in 4 hospitals in Ontario, Canada.[100] For women with GDM compared with healthy women, the adjusted ORs for exclusive breastfeeding in the hospital and at discharge were 0.77 (95% CI, 0.68-0.87) and 0.75 (95% CI, 0.66-0.85), respectively. There were no differences between these groups in terms of intention to breastfeed (OR: 0.98; 95% CI, 0.78-1.22).

Oza-Frank and colleagues examined differences in breastfeeding initiation and continuation (defined as continuing to breastfeed for at least 2 months) between women with and without a history of GDM (N = 72,755) using cross-sectional data from the CDC's Pregnancy Risk Assessment Monitoring System (PRAMS), 2009-2011.[98] Although breastfeeding initiation rates were similar among women with and without GDM (80.8% vs. 82.2%, P = .20), as in our study, continuation was slightly lower among GDM women (65.7% vs. 68.8%, P = .01). In contrast, we did not observe differences in duration of any breastfeeding between groups. Oza-Frank et al. did not assess initiation or duration of exclusive breastfeeding, however.

Finally, our findings were consistent with those of Kozihmannil et al., who reported reduced odds of exclusive breastfeeding, defined as giving only breast milk, at 1 week postpartum among women who had "medically complex" pregnancies (adjusted OR, 0.69; 95% CI, 0.48-1.00). In this study, mothers were considered to have a medically complex pregnancy if they were taking blood pressure medication prior to pregnancy, had gestational or pre-gestational diabetes (type 1 or type 2), or had a prepregnancy BMI greater than 30. In contrast with our findings, Kozihmannil and colleagues also observed significantly reduced intention to breastfeed for women with medically complex pregnancies (adjusted OR; 0.71, 95% CI, 0.52-0.98).

Overall, our estimates of early exclusive breastfeeding rates among women with GDM pregnancies are consistent with previous studies, though some identified differences in initiation and/or duration of any breastfeeding that we did not observe in the present study.

8.6 Conclusions and Implications

Our prospective study found that women with gestational diabetes were less likely to ever breastfeed exclusively and were more likely to supplement with formula in the hospital. Women with GDM were not less likely to intend to breastfeed (exclusively or at all) or to initiate any breastfeeding. Furthermore, GDM women who initiated any or exclusive breastfeeding did not have shorter durations of any and exclusive breastfeeding, respectively, compared with nondiabetic women. These findings suggest that differences in initiation of exclusive breastfeeding may be related to formula supplementation or other factors occurring in the hospital, rather than to problems experienced after discharge. The reasons for the increased rate of formula supplementation are not clear and warrant further study.

Table 3.1. Demographic characteristics of prenatal and postnatal respondents by maternal gestational diabetes status

	Prenatal Sample (*N*=3,244)			Postnatal Sample (*N*=2,051)		
Characteristic	NDM (*n*=3,032) *n* (%)	GDM (*n*=212) *n* (%)	*P*	NDM (*n*=1,918) *n* (%)	GDM (*n*=133) *n* (%)	*P*
Primiparous	859 (28.3)	55 (25.9)	.46	492 (25.7)	31 (23.3)	.55
Maternal pre-pregnancy BMI (kg/m^2)			<.001			<.001
<18.5	149 (4.9)	2 (0.9)		92 (4.7)	0 (0.0)	
18.5-<25	1,426 (47.0)	58 (27.4)		899 (46.9)	35 (26.3)	
25-<30	766 (25.3)	53 (25.0)		486 (25.3)	34 (25.6)	
≥ 30	691 (22.8)	99 (46.7)		442 (23.0)	64 (48.1)	
Mother's race/ethnicity			.19			.31
Non-Hispanic White	2,527 (83.3)	179 (84.4)		1,642 (85.6)	115 (86.5)	
Non-Hispanic Black	168 (5.5)	5 (2.4)		85 (4.4)	2 (1.5)	
Hispanic	194 (6.4)	15 (7.1)		112 (5.8)	8 (6.0)	
Other	143 (4.7)	13 (6.1)		79 (4.1)	8 (6.0)	
Mother's education			.38			.57
HS or less	697 (23.0)	55 (25.9)		378 (19.7)	29 (21.8)	
Some college	1,256 (41.4)	78 (36.8)		766 (39.9)	47 (35.3)	
College graduate or more	1,079 (35.6)	79 (37.3)		774 (40.4)	57 (42.9)	
Maternal age			<.001			<.001
18-24	701 (23.1)	28 (13.2)		375 (19.6)	12 (9.0)	

25-29	1,010 (3.3)	57 (26.9)		653 (34.1)	37 (27.8)	
30-34	860 (28.4)	67 (31.6)		586 (30.6)	47 (35.4)	
≥ 35	461 (15.2)	60 (28.3)		304 (15.9)	37 (27.8)	
Income as % of poverty level			.26			.51
<185	1,316 (43.4)	84 (29.6)		790 (41.2)	48 (36.1)	
185-349	1,071 (35.3)	73 (34.4)		693 (36.1)	53 (39.9)	
≥ 350	645 (21.3)	55 (25.9)		435 (22.7)	32 (24.1)	
Mother smoked during pregnancy	325 (10.7)	31 (14.6)	.08	155 (8.1)	17 (12.8)	.06
Marital status- not married	696 (23.0)	46 (21.7)	.67	368 (19.3)	22 (16.7)	.31
Mother or child enrolled in WIC during pregnancy	939 (31.0)	72 (34.0)	.36	654 (34.1)	48 (36.1)	.64
Mother's employment status			.69			.18
Employed full-time	1,045 (34.5)	75 (35.4)		660 (34.4)	51 (38.4)	
Self-employed or part-time	573 (18.9)	35 (16.5)		386 (20.1)	18 (13.5)	
Not employed	1,414 (46.6)	102 (48.1)		872 (45.5)	64 (48.1)	
Gestational weight gain						<.001
Q1 <23 lbs				454 (23.7)	69 (51.9)	
Q2 23-<30 lbs				338 (17.6)	22 (16.5)	
Q3 30-<40 lbs				583 (30.4)	26 (19.6)	
Q4 ≥ 40 lbs				543 (28.3)	16 (12.0)	
Birth weight, kg, mean (SD)				3.47 (0.48)	3.54 (0.47)	.03
Infant sex, female				992 (51.7)	61 (45.9)	.19
						<.001

≥ 39 weeks	1,268 (66.1)	62 (46.6)	
37-38 weeks	563 (29.4)	68 (51.1)	
35-36 weeks	87 (4.5)	3 (2.3)	
Birth weight category			.11†
AGA	1,649 (86.0)	109 (82.0)	
SGA	60 (3.1)	2 (1.5)	
LGA	209 (10.9)	22 (16.5)	
Type of delivery			<.01
Vaginal, not induced	751 (39.2)	39 (29.3)	
Vaginal, induced	661 (34.5)	41 (30.8)	
Planned C-section	302 (15.8)	35 (26.3)	
Unplanned C-section	204 (10.6)	18 (13.5)	
Any medication used during labor	1,616 (84.4)	113 (85.6)	.72
Infant stayed in the NICU	45 (2.4)	5 (3.8)	.31

P values obtained by X^2 tests for categorical variables and Wilcoxon rank sum tests for continuous variables
† Fisher's exact test

Table 3.2. Estimated unadjusted and adjusted odds ratios for breastfeeding outcomes for GDM vs. NDM

	OR (95% CI)	Adjusted OR (95% CI) [a]
Breastfeeding intentions (*N*=3,244; GDM cases=212)		
Intent to breastfeed, any	0.88 (0.62-1.27)	0.96 (0.66-1.41)[b]
Intent to breastfeed exclusively	0.70 (0.53-0.93)	0.76 (0.57-1.03)[b]
Breastfeeding practices (*N*=2,051, GDM cases=133)		
Ever breastfed	0.64 (0.41-1.02)	0.72 (0.44-1.19)[c]
Ever exclusively breastfed	0.51 (0.35-0.74)	0.64 (0.43-0.96)[c]
Ever exclusively breastfed, among women who intended to EBF (*N* =1,293; GDM cases=76)	0.51 (0.32-0.81)	0.61 (0.36-1.01)[c]
Baby was fed formula in the hospital, among women who ever breastfed (*N* =1,685, GDM cases=107)	2.19 (1.47-3.26)	1.78 (1.16-2.74)[c]

a All models adjusted for maternal age, pre-pregnancy BMI, race, parity, education, WIC participation, and employment status

b Additionally adjusted for marital status

c Additionally adjusted for gestational weight gain, maternal smoking, type of delivery, income, infant birth weight category, infant gestational age at birth and NICU stay

Table 3.3. Duration of any and exclusive breastfeeding (in weeks), and percent of milk feeds that were breast milk (months 0-6), by GDM status

	Mean (SD)		
	NDM	GDM	*P*
Breastfeeding outcomes among all postnatal respondents (*N*=2,045; GDM cases=132)			
Duration of any breastfeeding, weeks	23.64 (20.28)	21.83 (20.00)	.22
Duration of exclusive breastfeeding, weeks	6.10 (9.02)	4.20 (7.83)	.001
Breast milk % of milk feeds	55.74 (43.36)	48.70 (44.18)	.07
Breastfeeding outcomes among mothers who initiated breastfeeding or EBF			
Duration of any breastfeeding, among women who ever breastfed (*N*=1,772; GDM cases=107)	27.17 (19.42)	26.93 (18.85)	.91
Duration of EBF, among women who ever breastfed exclusively (*N*=956; GDM cases=42)	12.78 (9.23)	13.19 (8.63)	.69
Breast milk % of milk feeds, among women who ever breastfed exclusively (*N*=956; GDM cases=42)	76.29 (34.95)	85.28 (23.92)	.49

*P*s determined by Wilcoxon rank sum tests

Table 3.4. Comparison of mother-infant pairs included and excluded from prenatal sample because of missing data, N=4,902

Characteristic	Excluded (*n*=1,658) *n* (%)	Included (*n*=3,244) *n* (%)	*P*
Diagnosed with GDM (*N*=4,369)	65 (5.8)	212 (6.5)	.37
Primiparous (*N*=4,603)	572 (42.1)	914 (28.2)	<.001
Maternal pre-pregnancy BMI (*N*=4,711)			.05
<18.5	93 (6.3)	151 (4.7)	
18.5-<25	688 (46.9)	1,484 (45.8)	
25-<30	341 (23.2)	819 (25.3)	
≥ 30	345 (23.5)	790 (34.4)	
Mother's race/ethnicity (*N*=4,754)			<.001
White	1,147 (76.6)	2,706 (83.4)	
Black	127 (8.3)	209 (6.4)	
Hispanic	126 (8.3)	209 (6.4)	
Other	100 (6.6)	156 (4.8)	
Mother's education (*N*=4,278)			<.001
HS or less	304 (29.4)	752 (23.2)	
Some college	423 (40.9)	1,334 (41.1)	
College graduate or more	307 (26.7)	1,158 (35.7)	
Maternal age (*N*=4,890)			<.001
18-24	650 (39.5)	729 (22.5)	
25-29	514 (31.2)	1,067 (32.9)	
30-34	291 (17.7)	927 (28.6)	
≥ 35	191 (11.6)	521 (16.1)	
Income as % of poverty level (*N*=4,784)			<.001

<185	763 (49.6)	1,400 (43.2)	
185-349	497 (32.3)	1,144 (35.3)	
≥ 350	280 (18.2)	700 (21.6)	
Mother smoked during pregnancy (*N*=4,752)	228 (15.1)	356 (11.0)	<.001
Marital status- not married (*N*=4,306)	325 (30.6)	742 (22.9)	<.001
Mother enrolled in WIC during pregnancy (*N* =4,893)	730 (44.3)	1,011 (31.2)	<.001
Mother's employment status (*N*=3,981)			.40
Full-time	290 (39.4)	1,310 (40.4)	
Self-employed or part-time	127 (17.2)	608 (18.7)	
Not employed	320 (43.4)	1,326 (40.9)	

P values were obtained by Wilcoxon rank sum test for continuous variables and X^2 tests for categorical variables

Table 3.5. Comparison of mother-infant pairs included and excluded from postnatal sample because of missing data, *N*=3,033

Characteristic	Excluded (*n*=982) *n* (%)	Included (*n*=2,051) *n* (%)	*P*
Diagnosed with GDM (*N*=2,734)	41 (6.0)	133 (6.5)	.66
Primiparous (*N*=2,835)	305 (38.9)	523 (25.5)	<.001
Maternal pre-pregnancy BMI (kg/m^2) (*N*=2,879)			.83
<18.5	42 (5.1)	91 (4.4)	
18.5-<25	368 (44.4)	934 (45.5)	
25-<30	217 (26.2)	520 (25.4)	
≥ 30	201 (24.3)	506 (24.7)	
Mother's race/ethnicity (*N*=2,948)			.02
White	730 (81.4)	1,757 (85.7)	
Black	56 (6.2)	87 (4.2)	
Hispanic	63 (7.0)	120 (5.9)	
Other	48 (5.4)	87 (4.2)	
Mother's education (*N*=2,783)			<.01
HS or less	177 (24.2)	407 (19.8)	
Some college	307 (41.9)	813 (39.6)	
College graduate or more	248 (33.9)	831 (40.5)	
Maternal age (*N*=3,028)			<.001
18-24	316 (32.3)	387 (18.9)	
25-29	329 (33.7)	690 (33.6)	
30-34	201 (20.6)	633 (30.9)	
≥ 35	131 (13.4)	341 (16.6)	
Income as % of poverty level (*N*=2,915)			.07
<185	392 (45.4)	838 (40.9)	

185-349	296 (34.3)	746 (36.4)	
≥ 350	176 (20.4)	467 (22.8)	
Mother smoked during pregnancy (*N*=2,904)	122 (14.3)	172 (8.4)	<.001
Marital status- not married (*N*=2,801)	196 (25.9)	390 (19.1)	<.001
Mother or child enrolled in WIC (3,029)	446 (45.6)	702 (34.2)	<.001
Mother's employment status (*N*=2,578)			.32
Full-time	205 (38.9)	811 (39.5)	
Self-employed or part-time	91 (17.3)	404 (19.7)	
Not employed	231 (43.8)	836 (40.8)	
Weeks of maternity leave, mean (SD) (*N*=1,501)	9.85 (15.32)	9.10 (11.08)	.28
Gestational weight gain (*N*=2,800)			.05
Q1 <23 lbs	176 (23.5)	523 (25.5)	
Q2 23-<30 lbs	116 (15.5)	360 (17.6)	
Q3 30-<40 lbs	214 (28.6)	609 (29.7)	
Q4 ≥ 40 lbs	243 (32.4)	559 (27.3)	
Infant sex-female (*N*=3,030)	476 (48.6)	1,053 (51.3)	.16
Baby stayed in the NICU	26 (2.7)	50 (2.4)	.73
Birth weight, kg, mean (SD) (*N*=2,915)	3.41 (0.47)	3.47 (0.48)	<.01
Gestational age at birth			
≥39 weeks	559 (64.7)	1,330 (64.9)	
37-38 weeks	256 (29.6)	631 (30.8)	
35-36 weeks	49 (5.7)	90 (4.4)	
Birth weight category (*N*=2,912)			.04
AGA	736 (85.5)	1,758 (85.7)	
SGA	41 (4.8)	62 (3.0)	
LGA	84 (9.8)	231 (11.3)	
Ever breastfed	809 (82.4)	1,777 (86.6)	.002

P values were obtained by Wilcoxon rank sum tests for continuous variables and X^2 tests for categorical variables

Table 3.6. Inverse-probability-weighted regression models of breastfeeding outcomes for GDM vs. NDM

	OR (95% CI)	Adjusted OR (95% CI) [a]
Breastfeeding intentions, *N*=3,244; GDM cases=212		
Intent to breastfeed, any	0.87 (0.61-1.25)	0.96 (0.65-1.41)[b]
Intent to breastfeed exclusively	0.70 (0.52-0.93)	0.76 (0.56-1.03)[b]
Breastfeeding practices, *N*=2,043; GDM cases=132		
Ever breastfed	0.66 (0.42-1.05)	0.75 (0.45-1.27)[c]
Ever exclusively breastfed	0.51 (0.35-0.75)	0.65 (0.44-0.97)[c]
Ever exclusively breastfed, among women who intended to EBF (*N* =1,288; GDM cases=76)	0.52 (0.33-0.84)	0.63 (0.38-1.06) [c]
Baby was fed formula in the hospital, among women who ever breastfed (*N* =1,685; GDM cases=107)	2.16 (1.45-3.21)	1.77 (1.15-2.71) [c]

a All models adjusted for maternal age, pre-pregnancy BMI, race, parity, education, WIC participation, and employment status
b Additionally adjusted for marital status
c Additionally adjusted for gestational weight gain, maternal smoking, type of delivery, income, infant birth weight category, infant gestational age at birth and NICU stay

CHAPTER 9

A COMPARISON OF INFANT FEEDING ATTITUDES AND POSTPARTUM BREASTFEEDING EXPERIENCES AMONG WOMEN WITH GESTATIONAL DIABETES MELLITUS AND NONDIABETIC WOMEN

9.1 Background

Breastfeeding has important benefits for women with a history of gestational diabetes mellitus (GDM) and their infants,[19,83-86] including improved short-term insulin sensitivity and glucose homeostasis among postpartum women with GDM. [87-90] Long-term effects are less certain, but some studies have observed associations between longer duration of breastfeeding and improved insulin sensitivity[96] or reduced risk of type 2 diabetes.[95] A few studies have also found a protective association between breastfeeding and type 2 diabetes risk among offspring of women with GDM.[24-26]

Despite the established benefits of breastfeeding for all women and infants, and the possible benefits for women with GDM and their children in particular, there is some evidence that breastfeeding initiation, duration, and exclusivity may be lower among women with GDM. [98-100,111] We previously demonstrated (unpublished data, 2015) that women with GDM in the U.S. Infant Feeding Practices Study II (IFPS II) cohort were nearly 40% less likely to initiate exclusive breastfeeding compared with their nondiabetic counterparts (adjusted OR, 0.64; 95% CI, 0.43-0.96). It is not clear why women with GDM appear to have less favorable breastfeeding outcomes compared with nondiabetic mothers. Delayed onset of lactation[28,29] is more common among women with any form of diabetes during pregnancy, but other problems with breastfeeding are not well-documented. However, breastfeeding problems at home and inadequate breastfeeding

support were significantly associated with early breastfeeding cessation (≤ 3 months) in one study of Australian women with recent GDM.[116]

A range of psychosocial factors likely contributes to breastfeeding intentions and practices.[30-33] Positive maternal attitudes toward the relative benefits and drawbacks of breastmilk versus formula and breastfeeding in public are associated with increased breastfeeding duration.[30] Comfort breastfeeding in front of friends or in public;[32] knowledge, attitudes, and beliefs about breastfeeding;[32]; and perceptions of other's opinions about infant feeding[33] have all been associated with intention to exclusively breastfeed. Although several studies have examined breastfeeding behaviors in women with GDM, we are not aware of any that have investigated the psychosocial factors and early postpartum experiences that might contribute to reduced breastfeeding in this population. The objectives of the present study were to estimate associations between GDM and 1) breastfeeding knowledge, attitudes, and beliefs during pregnancy; and 2) postpartum hospital experiences and breastfeeding problems in the first 2 weeks following delivery.

9.2 Methods

9.2.1 Sample

Data from the Infant Feeding Practices Study II (IFPS II) cohort were used to carry out this study.[124] The IFPS II was conducted jointly by the U.S. Food and Drug Administration and the Centers for Disease Control and Prevention (CDC). The longitudinal study followed mother-infant dyads from late pregnancy to the infant's first birthday. Data were collected between May 2005 and June 2007 using a series of mailed questionnaires, one administered prenatally and 10 at approximately monthly intervals

after the infant's birth. A brief phone interview was conducted around the time of the infant's expected birth to confirm eligibility. For this study, we used data from the prenatal and neonatal questionnaires and the phone interview. Women who indicated being in their third trimester of pregnancy were eligible to be included in the study. Exclusion criteria included multiple gestation, gestational age at birth less than 35 weeks, birth weight less than 5 lbs, and stay in intensive care >3 days. Additionally, mother-infant pairs were excluded if the infant had a medical condition that would affect feeding. Details of study's methodology have been published elsewhere.[124]

A total of 4,902 pregnant women enrolled in the study and 3,033 completed the first postnatal questionnaire. The sample was drawn from a consumer opinion panel of >500,000 U.S. households. For analyses of breastfeeding attitudes, beliefs and perceptions—assessed during pregnancy—our sample included 3,010 women who completed the prenatal questionnaire and had complete data for all outcome variables and relevant covariates. For analyses of perinatal factors, our sample was comprised of 1,733 mother-infant dyads who completed a neonatal questionnaire and were not missing data for variables of interest.

9.2.2 Exposure

Maternal gestational diabetes was measured by a single item in the prenatal questionnaire, which was completed during the third trimester of pregnancy. The question asked respondents whether they had been diagnosed with gestational diabetes in the current pregnancy. Women who indicated a diagnosis with type 1 or type 2 diabetes were excluded.

9.2.3 Primary Outcome Measures

At the prenatal time point, primary outcomes were participants' beliefs about the value of breastfeeding, perceptions of the opinions of family and medical professionals about infant feeding, and plans for breastfeeding. These included the respondent's opinion of "the best way to feed a baby," which we categorized into breastfeeding vs. any other response, which included "a mix of both breast and formula feeding," "formula feeding," or "breastfeeding and formula feeding are equally good ways to feed a baby." A 5-point scale was used to indicate level of agreement with each of the following statements: "Infant formula is as good as breast milk," "If a baby is breastfed, he or she will be less likely to get ear infections," "If a baby is breastfed he or she will be less likely to become obese," and "Babies should be exclusively breastfed (fed only breast milk) for the first 6 months." For each of these variables, we collapsed responses into 2 categories: "somewhat or strongly agree" and "neutral, somewhat disagree, or strongly disagree."

Respondents were then asked to respond to "How do the following people think your baby should be fed in the first few weeks?" for the baby's father, the respondent's mother, the respondent's mother-in-law, respondent's obstetrician or other doctor, and the baby's pediatrician or other doctor. Responses were "only breastfed," "only formula fed," "both breast and formula fed," "no opinion or don't know," and "no one in this category." For analyses of these variables, we set the latter value to missing. We also considered the number of respondent's friends and relatives who had breastfed their children (1 or 2, 3-5, more than 5, none have breastfed, or none have children/don't know). Finally, we assessed the association between GDM and confidence in the ability

to breastfeed as long as planned (somewhat or very confident vs. neutral to not at all confident) among women who indicated an intention to breastfeed.

At the postnatal time point, primary outcomes were neonatal factors and hospital experiences that could affect breastfeeding. These included how long after delivery the mother breastfed or tried to breastfeed for the first time (< 30 minutes, 30 to 60 minutes, 1 to 2 hours, 3 to 6 hours, 7 to 12 hours, or 13 to 24 hours), whether anyone helped the mother with breastfeeding in the hospital (yes or no), how many hours after the baby's birth the mother first got help with breastfeeding (< 30 minutes, 30 to 60 minutes, 1 to 2 hours, 3 to 6 hours, 7 to 12 hours, or 13 to 24 hours), whether the baby stayed in the mother's room in the hospital "except for doctor visits, bathing, or other treatments" ("yes, all the time" vs. "yes, some nights but not all" or "no"). Respondents were asked separately whether the baby was given sugar water, formula, or a pacifier while in the hospital (yes, no, or don't know). For these items, responses of "don't know" were set to missing. Time until milk came in (1 day, 2 days, 3 days, 4 days, or more than 4 days) and problems experienced with breastfeeding in the first 2 weeks were also assessed. Respondents indicated these using a checklist that included 17 possible problems. Because all of the above questions, with the exception of pacifier use, were asked only of respondents who ever breastfed or tried to breastfeed, our postnatal analyses were necessarily limited to women who initiated breastfeeding.

9.2.4 Other Measures

Maternal age at delivery was grouped into the following categories: 18-24, 25-29, 30-34, and ≥ 35. Attained education was categorized into three levels: high school or less, some college, college graduate. Other maternal characteristics included household

income as percent of the federal poverty level (<185%, 185-349%, or ≥ 350%), parity (primiparous or multiparous), smoking status during pregnancy (any smoking or no smoking), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, or other), marital status (currently married nor not married), employment status (full-time, self-employed or part-time, or not employed). Maternal pre-pregnancy BMI (kg/m^2) was calculated based on self-reported weight and height and was then categorized (<18.5, underweight; 18.5-<25.0, normal weight; 25.0-<30.0, overweight; or ≥ 30.0, obese). We grouped gestational weight gain (lbs) into quartiles. Gestational age at birth in weeks was determined from infant's birth date, reported in the phone interview, and the due date indicated in the prenatal questionnaire. We categorized gestational age into three levels (≥ 39 weeks, 37-38 weeks, or <37 weeks). Infant sex and birth weight were reported by the mother in a phone screener after delivery. Birth weight category was determined using Olsen et al.'s intrauterine growth curves.[126] Birth weight for gestational age and gender at < 10^{th} percentile was considered SGA, while birth weight > 90^{th} percentile was considered LGA. Type of delivery (vaginal, not induced; vaginal, induced; unplanned Cesarean section; or planned Cesarean section) was assessed in the postnatal questionnaire. Finally, participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) was assessed by prenatal and postnatal questionnaires and dichotomized (mother or child ever enrolled or neither mother nor child ever enrolled).

9.2.5 Statistical Analysis

Frequency distributions and means and standard deviations were calculated to describe the overall prenatal and postnatal samples. Bivariate analyses were carried out

using Wilcoxon rank sum tests and χ^2 tests, as appropriate, to determine associations between GDM status and most outcome variables and covariates. Multivariable logistic regression models were built to determine adjusted odds ratios for any outcome variables that were associated with GDM in bivariate analyses, with a *P* value <.10. Categorical outcomes were dichotomized where appropriate. All variables considered as possible confounders were entered into initial multivariable logistic regression models. We then employed stepwise removal of non-significant covariates to achieve more parsimonious models. The criterion for significance was a likelihood ratio test *P* value of ≤ 0.10 or a change in the estimated coefficient for the primary predictor of interest of 10% or more when the covariate was removed. We retained maternal age, race/ethnicity, and BMI in the multivariable models regardless of significance.

Finally, to determine the extent to which our final sample resembled the initial IFPS II cohort of mothers and infants who qualified for the study but were not included in our study because of missing data, we compared these groups on several key characteristics. To overcome possible selection bias and reweight the models back to the source population, we used inverse probability weighted modeling.[136] The weights were the inverse of the probability of inclusion in the final prenatal and postnatal samples, given covariates associated with inclusion based on logistic regression models (*P* <.10).

The overall fit of logistic regression models was assessed using the Hosmer-Lemeshow test. Stata version 11.0 was used for all analyses (Stata Corporation, College Station, TX), and two-tailed *P* values of < .05 were considered statistically significant.

9.3 Results

Women in the prenatal and postnatal samples were largely non-Hispanic White (83.8% and 84.7%), between the ages of 25 and 34 (61.7% and 64.9%), and married (77.8% and 82.1%). Most had at least some college education (77.6% and 82.9%), and the vast majority did not smoke during pregnancy (89.2% and 93.2%). Approximately 6.5% reported being diagnosed with GDM during the current pregnancy. Descriptive statistics for all relevant characteristics, by GDM status, are presented for the prenatal and postnatal samples in Table 4.1. Women with GDM were significantly more likely to give birth at 37-38 weeks of gestation vs. 39 weeks or later (P <.001), were more likely to be overweight or obese (P <.001), and older (P <.001). Women with GDM gained less weight during pregnancy (P <.001) and were more likely to deliver by planned or unplanned Cesarean section (P <.01). Finally, more infants of mothers with GDM were born large-for-gestational age (LGA) (P =.03).

Bivariate analyses of breastfeeding knowledge, attitudes, and beliefs among GDM vs. NDM women in the prenatal sample (Table 4.2) showed that a greater proportion of GDM women said that exclusive breastfeeding is the best way to feed a newborn (59.0% vs. 70.5%, P<.01) and more GDM women agreed with the statement "infant formula is just as good as breastmilk" (34.4% vs. 26.8%, P =.02). Respondents with GDM were also less likely to say that their baby's father (P <.01), their own mother (P =.04), or their obstetrician or other doctor (P =.03) believed the baby should be only breastfed. There was a tendency toward reduced support for breastfeeding from the respondent's mother-in-law (P =.07). Among women who intended to breastfeed, women with GDM were less likely to report feeling comfortable breastfeeding in front of close women friends (60.0%

vs. 68.6%, *P* =.02) and less likely to report feeling confident in their ability to breastfeed as long as planned (61.6% vs. 70.0%, *P* =.03).

After adjustment for demographic characteristics, significant associations remained between GDM and the baby's father's opinion and the mother's doctor's opinion about how the baby should be fed (Table 4.3). Women with GDM were more likely to say that the baby's father was in favor of formula feeding only (adjusted OR, 1.75; 95% CI, 1.02-2.97) or mixed feeding (adjusted OR, 1.78; 95% CI, 1.21-2.61) as compared to breastfeeding only. GDM women were nearly 3 times more likely to say that their doctor believed the baby should be formula fed (adjusted OR, 2.82; 95% CI, 1.17-6.79). Comfort breastfeeding in front of close women friends also remained significantly reduced among GDM women (adjusted OR, 0.70; 95% CI, 0.50-0.98). Although our final prenatal sample differed in many ways from IFPS II respondents we excluded because of missing data (Table 4.4), the results of inverse-probability-weighted logistic regression analyses were similar to the unweighted estimates (Table 4.5).

Analyses of postnatal outcomes showed that although women with GDM were just as likely as NDM women to breastfeed within one hour of delivery (*P* =.30), they were less likely to get help with breastfeeding within one hour of delivery (*P* =.05). GDM women reported later onset of lactation overall (*P* <.01). However, the rate of "delayed onset of lactation," defined as > 72 hours postpartum, was not significantly different between GDM and NDM groups (*P* =.14). Breastfeeding problems in the first 2 weeks reported by mothers were mostly similar between groups, but four were significant (*P* <.05) or nearly significant (*P* <.10). GDM women were more likely to indicate that their baby had trouble sucking (*P* =.01) or was not interested in breastfeeding (*P* =.03), that

their milk took too long to come in (P =.05), and that they experienced some other problem (P =.09). Among women whose infants did not require a NICU stay, women with GDM were less likely to say that their infant stayed in their room in the hospital all of the time (P <.01).

Unadjusted analyses of associations between GDM and postnatal outcomes are presented in Table 4.6. After adjusting for demographic and perinatal factors, GDM was significantly associated with reduced odds of the infant staying in the mother's hospital room (adjusted OR, 0.55; 95% CI, 0.36-0.85) and increased odds of the mother reporting that the baby had trouble sucking (adjusted OR, 1.66; 95% CI, 1.08-2.54) or was not interested in breastfeeding (adjusted OR, 2.06; 95% CI, 1.07-3.98) (Table 4.7). GDM was associated with reduced odds of reporting "some other problem" with breastfeeding (adjusted OR, 0.23; 95% CI, 0.05-0.99). However, the prevalence of "some other problem" was low in both groups (1.9% in GDM and 5.7% in NDM). There were no significant associations between GDM and delayed onset of lactation, getting help with breastfeeding later than 1 hour after delivery, or reporting late onset of lactation as a problem.

As in the prenatal sample, there were several differences between our postnatal sample and participants who completed a postnatal questionnaire but were excluded because of missing data (Table 4.8). Inverse-probability-weighted estimates were largely consistent with the unweighted estimates (Table 4.9). However, the association between GDM and the infant's reported lack of interest in breastfeeding was no longer statistically significant (adjusted OR, 1.97; 95% CI, 0.97-4.01), though the OR was not substantially

changed. The Hosmer-Lemeshow test indicated there was no significant lack of fit in any of our models.

9.4 Discussion

In the present study, we found that GDM was independently associated with a number of factors that may contribute to reduced initiation of exclusive breastfeeding in this population. Pregnant women with GDM were less likely to say that breast milk was the best way to feed a newborn, were more likely to report that formula feeding was the preferred feeding method of their infants' fathers and their own doctors, and were less likely to be comfortable breastfeeding in front of close women friends. After delivery, infants of women with GDM were less likely to consistently room-in with the mother at the hospital. GDM mothers who tried to breastfeed indicated that their infants had problems with sucking or were not interested in breastfeeding more often than nondiabetic mothers.

Previous research has shown that breastfeeding intentions are strong predictors of breastfeeding behavior,[33,51] and attitudes toward breastfeeding are predictive of both intentions[32] and behavior. [30] Stuebe and Bonuck have demonstrated that knowledge, attitudes and beliefs about breastfeeding are associated with intent to exclusively breastfeed in an urban, largely Hispanic population.[32] In their study, women who disagreed with the statement "infant formula is as good as breastmilk" (adjusted OR, 3.44; 95% CI, 1.80-6.59) and agreed with the statement "babies should be fed only breastmilk for the first 6 months" (adjusted OR, 7.54; 95% CI, 3.21-15.78) were substantially more likely to intend to breastfeed exclusively. In our study, there were no significant differences between GDM and NDM women in their agreement with these

statements. However, women with GDM were less likely to say that breastfeeding is the best way to feed a baby in the first few weeks of life, suggesting somewhat less favorable attitudes towards breastfeeding compared to formula feeding.

In the same study by Stuebe and Bonuck,[32] women who were comfortable breastfeeding in front of other people were more likely to plan to exclusively breastfeed. Comfort breastfeeding in front of close women friends (adjusted OR, 1.77; 95% CI, 1.26-2.49), in front of men and women the mother is close to (adjusted OR, 1.72; 95% CI, 1.27-2.32) and in public (adjusted OR, 1.63; 95% CI, 1.16-2.30) were all associated with increased odds of planning to breastfeed exclusively vs. mixed feeding. In their European cohort study, Scott et al. found that mothers who had ever breastfed in public had substantially reduced risks of discontinuing breastfeeding within 12 months.[137] Compared to multiparas who had never breastfed in public, adjusted ORs for primiparas and multiparas who reported breastfeeding in public were 0.50 (95% CI, 0.30-0.81) and 0.47 (0.29-0.77), respectively. In our study, women with GDM were 30% less likely to feel comfortable breastfeeding in front of close women friends. Although there were no differences in comfort breastfeeding in front of other people, this may be because women in our sample were less comfortable breastfeeding in front of mixed-gender groups overall. While 68.0% were comfortable breastfeeding in front of women friends, only 40.2% were comfortable breastfeeding in front of men and women they were close to, and just 19.8% were comfortable breastfeeding in front of men and women who were not friends. It seems likely that U.S. women are less comfortable breastfeeding in front of others, compared with women in other countries. In the study by Scott et al., the

proportion of women who had breastfed in public ranged from a low of 36.3% in Italy to a high of 78.4% in Sweden, with an average of 59.1% across 4 countries.[137]

Bai and colleagues found that attitude toward breastfeeding and subjective norm—perceptions of others' agreement that babies should be exclusively breastfed for 6 months—were significantly correlated with intention to exclusively breastfeed for 6 months,[33] suggesting that the opinions of members of a mother's social group may be an important determinant of feeding intentions. In their Australian cohort, Scott et al. reported that women whose baby's fathers preferred breastfeeding were about 9 times more likely to breastfeed at hospital discharge (adjusted OR, 9.13; 95% CI, 4.83-17.26).[138] There was a smaller but still significant effect of the baby's maternal grandmother's preference for breastfeeding (adjusted OR, 2.16; 95% CI, 1.15-4.03). They did not measure feeding preference of medical professionals. We found that women with GDM were more likely to report that their baby's fathers preferred formula-feeding or mixed feeding. It is not clear why fathers of women with GDM would be less supportive of breastfeeding, but this finding highlights the importance of including fathers in breastfeeding promotion efforts.

Research on factors contributing to breastfeeding intentions and practices in GDM women in particular are sparse. However, one study by Morrison et al. described factors associated with early cessation of breastfeeding among women with recent GDM.[116] In their study, breastfeeding problems at home (adjusted OR, 8.01; 95% CI, 4.57-14.05) and inadequate breastfeeding support from health professionals (adjusted OR, 1.88; 95% CI, 1.10-3.22) were associated with breastfeeding ≤ 3 months. We found that GDM women were more likely to experience some breastfeeding problems in the first two weeks

(which would include time in the hospital and at home), which may in turn contribute to poorer breastfeeding outcomes.

Problems with sucking and lack of interest in breastfeeding by the infant were more commonly reported by women with GDM. These problems may be related to differences in behavior of newborns of diabetic mothers. Several studies have observed poorer neuromotor behavioral responses in newborns of diabetic mothers,[139-141] which may in turn adversely affect early mother-infant interactions. Although sucking patterns have not been studied extensively in infants born to diabetic women, at least one study, by Bromiker et al. has reported impaired sucking pattern, as evidenced by fewer sucking bursts and total sucks, in newborns of women with insulin-treated GDM compared with nondiabetic mothers.[142] They did not, however, observe any differences between nondiabetic mothers and mothers with diet-treated GDM.

Although GDM women in our study were not less likely to get help with breastfeeding in the hospital, they were more likely to say that their doctors favored formula-feeding, suggesting that they may not be getting the same level of encouragement for breastfeeding from health professionals as their nondiabetic counterparts. A previous study, which also used IFPS II data, found that maternal perception of obstetrical provider's preference for infant feeding (exclusive breastfeeding vs. neutral) was associated with exclusive breastfeeding at 1 month (adjusted OR, 1.73; 95% CI, 1.33-2.24) and 3 months (adjusted OR, 1.41; 95% CI, 1.09-1.80).[143] Physician support for breastfeeding in GDM patients has not been well-studied. Recent U.S. studies have found that most obstetricians report providing some support for breastfeeding. Sims and colleagues found that 75% of American College of Obstetrics and Gynecology

(ACOG) members in the District of Columbia region counseled most patients on breastfeeding,[144] and Taveras et al. reported 93% of obstetricians in a Boston, Massachusetts area medical group encouraged their patients to breastfeed exclusively. [142] However, physicians in both studies also acknowledged several barriers to providing breastfeeding support, with lack of time among the most commonly cited (52-66%)[144,145] We are not aware of any studies that have assessed breastfeeding support among obstetrical providers with regard to GDM patients specifically, but we speculate that lack of time may be an especially important barrier when the patient is diabetic. The time required for GDM management may further limit the time available to provide counseling on infant feeding.

This study contributes important knowledge on psychosocial factors and early postpartum experiences that may influence breastfeeding practices of GDM women. Because the study was prospective and included data collected during pregnancy, we were able to assess differences in breastfeeding attitudes during pregnancy as well as postpartum experiences. The likelihood of misclassification of early breastfeeding outcomes is low because respondents completed the neonatal questionnaire within the first few weeks of birth. However, misclassification of the exposure, GDM, is possible because diagnosis was self-reported and not confirmed by biochemical measures. Finally, the association between GDM and our outcomes may differ by severity of GDM or treatment type (i.e. insulin-treated or diet-treated). Data were not collected for measures of severity or treatment, so we were unable to examine these groups separately.

Because our sample was not representative of the U.S. population, we cannot generalize our findings beyond this sample. The IFPS II cohort was comprised of women

who were motivated to complete multiple lengthy questionnaires. Such women likely differ in important ways from other women. Compared to a random sample of U.S. mothers of infants born in 1998-2000, mothers participating in IFPS II were older, more highly educated, less likely to have low income, less likely to smoke during pregnancy, and more likely to be white.[124] IFPS II participants were also more likely to be employed and reported longer maternity leaves compared to the representative U.S. sample. Within the IFPS II cohort, we also observed some significant differences between completers and non-completers for our analyses. To minimize the effect that these characteristics had on our results, we controlled for these and many other possible confounders. We used inverse probability weighted modeling to minimize the effect of any self-selection bias in our study, and this did not substantially alter our results. However, further research is needed to confirm our findings in populations of differing ethnic and socioeconomic backgrounds.

9.5 Conclusion

In the current study, women with GDM had less favorable attitudes and beliefs about breastfeeding during pregnancy, had less perceived support for breastfeeding from their physicians and their infants' fathers, and were more likely to be separated from their infants in the hospital and to experience specific problems with breastfeeding in the infant's first two weeks of life. These findings highlight the particular challenges of women with GDM and areas for future research on how best to support optimal breastfeeding in this group.

Table 4.1. Characteristics of participants, by maternal gestational diabetes status

	Prenatal Respondents (*N*=3,010)			Postnatal Respondents (*N*=1,733)		
Characteristic	NDM (*n*=2,815) *n* (%)	GDM (*n*=195) *n* (%)	*P*	NDM (*n*=1,626) *n* (%)	GDM (*n*=107) *n* (%)	*P*
Primiparous,	808 (28.7)	50 (25.6)	.36	437 (26.9)	24 (22.4)	.31
Maternal pre-pregnancy BMI (kg/m^2)			<.001			<.001†
<18.5	137 (4.9)	2 (1.0)		77 (4.7)	0 (0.0)	
18.5-<25	1,331 (47.3)	54 (27.7)		780 (48.0)	30 (28.0)	
25-<30	713 (25.3)	48 (4.6)		410 (25.2)	29 (27.1)	
≥ 30	634 (22.5)	91 (46.7)		359 (22.1)	48 (44.9)	
Mother's race/ethnicity			.11			.04†
White	2,360 (83.8)	163 (83.6)		1,376 (84.6)	92 (86.0)	
Black	150 (5.3)	4 (2.1)		73 (4.5)	0 (0.0)	
Hispanic	175 (6.2)	15 (7.7)		104 (6.4)	7 (6.5)	
Other	130 (4.6)	13 (6.7)		73 (4.5)	8 (7.5)	
Mother's education			.32			.39
HS or less	624 (22.2)	50 (25.6)		275 (16.9)	22 (20.6)	
Some college	1,168 (41.5)	71 (36.4)		663 (40.8)	37 (34.6)	
College graduate or more	1,023 (36.3)	74 (38.0)		688 (42.3)	48 (44.9)	
Maternal age			<.001			<.001
18-24	655 (23.3)	27 (13.9)		310 (19.1)	6 (5.6)	
25-29	947 (33.6)	53 (27.2)		567 (34.9)	34 (31.8)	

30-34	798 (28.4)	61 (31.3)		488 (30.0)	35 (32.7)	
≥ 35	415 (14.7)	54 (27.7)		261 (16.1)	32 (29.9)	
Income as % of poverty level			.40			.27
<185	1,190 (42.3)	80 (41.0)		647 (39.8)	35 (32.7)	
185-349	1,003 (35.6)	64 (32.8)		599 (36.8)	47 (43.9)	
≥ 350	622 (22.1)	51 (26.2)		380 (23.4)	25 (23.4)	
Mother smoked during pregnancy	296 (10.5)	30 (15.4)	.03	108 (6.6)	10 (9.4)	.28
Marital status- not married	624 (22.2)	44 (22.6)	.90	294 (18.1)	16 (15.0)	.41
Mother or child enrolled in WIC	843 (30.0)	66 (33.9)	.25	521 (23.0)	36 (33.6)	.73
Mother's employment status			.78			.22
Employed full-time	972 (34.5)	69 (35.4)		554 (34.1)	37 (34.6)	
Self-employed or part-time	534 (19.0)	33 (16.9)		336 (20.7)	15 (14.0)	
Not employed	1,309 (46.5)	93 (47.7)		736 (45.3)	55 (51.4)	
Perinatal Factors						
Gestational weight gain						<.001
Q1 <23 lbs				383 (23.6)	57 (53.3)	
Q2 23-<30 lbs				268 (16.5)	15 (14.0)	
Q3 30-<40 lbs				504 (31.0)	21 (19.6)	
Q4 ≥ 40 lbs				471 (29.0)	14 (13.1)	
Infant sex, female				830 (51.1)	49 (45.8)	.29
Birth weight, kg, mean (SD)				3.46 (0.46)	3.54 (0.49)	.07
Gestational age at birth						<.001†
≥ 39 weeks				1,066 (65.6)	46 (43.0)	

37-38 weeks	484 (29.8)	59 (55.1)	
35-36 weeks	76 (4.7)	2 (1.9)	
Birth weight category			.03†
AGA	1,403 (86.3)	85 (79.4)	
SGA	49 (3.0)	2 (1.9)	
LGA	174 (10.7)	20 (18.7)	
Type of delivery			<.01
Vaginal, not induced	641 (39.4)	32 (29.9)	
Vaginal, induced	563 (34.6)	33 (30.8)	
Planned C-section	243 (14.9)	27 (25.2)	
Unplanned C-section	179 (11.0)	15 (14.0)	
Any medication used during labor	1,369 (84.2)	90 (84.1)	.98
Infant stayed in the NICU	39 (2.4)	4 (3.7)	.27†

P values were obtained by X^2 tests for categorical variables and Wilcoxon rank sum tests for continuous variables
† Fisher's exact test

Table 4.2. Breastfeeding attitudes, beliefs, and perceptions of prenatal respondents, by GDM status (*N*=3,010)

Item	NDM (*n*= 2,815) *n* (%)	GDM (*n*=195) *n* (%)	*P*
Best way to feed a baby in the first few weeks			<.01
Breastfeed only	1,985 (70.5)	115 (59.0)	
Both breastfeed and formula feed	303 (10.8)	26 (13.3)	
Formula feed only	57 (2.0)	6 (3.1)	
Both equally good ways	470 (16.7)	48 (24.6)	
Somewhat or strongly agree with the following			
Formula is just as good as breastmilk	755 (26.8)	67 (34.4)	.02
Babies should be exclusively breastfed for the first 6 months (*N*= 2,995)	1,344 (48.0)	83 (42.8)	.16
Diarrhea is less likely in breastfed infants (*N*= 3,003)	1,415 (50.4)	88 (45.1)	.16
Ear infections are less likely in breastfed infants (*N*=3,004)	1,817 (64.7)	119 (61.3)	.35
Respiratory infections are less likely in breastfed infants (*N*=3,004)	1,832 (65.2)	121 (62.7)	.49
Obesity is less likely in breastfed infants (*N*=3,005)	1,058 (37.7)	71 (36.4)	.73
Father's opinion on how baby should be fed in the first few weeks			<.01
Only breastfed	1,514 (53.8)	84 (43.1)	
Only formula fed	180 (6.4)	20 (10.3)	
Both breastfed and formula fed	471 (16.7)	47 (24.1)	
No opinion	650 (23.1)	44 (22.6)	
Respondent's mother's opinion on how baby should be fed in the first few weeks			.04
Only breastfed	1,133 (40.3)	58 (29.7)	

Only formula fed	225 (8.0)	18 (9.2)	
Both breastfed and formula fed	456 (16.2)	37 (19.0)	
No opinion	1,001 (35.6)	82 (42.1)	
Respondent's mother-in-law's opinion on how baby should be fed in the first few weeks (*N*=2,807)			.07
Only breastfed	759 (28.9)	37 (20.7)	
Only formula fed	163 (6.2)	11 (6.2)	
Both breastfed and formula fed	345 (13.1)	21 (11.7)	
No opinion	1,361 (51.8)	110 (61.5)	
Mother's doctor's opinion on how baby should be fed in the first few weeks			.03
Only breastfed	1,219 (43.3)	75 (38.5)	
Only formula fed	35 (1.2)	7 (3.6)	
Both breastfed and formula fed	355 (12.6)	28 (14.4)	
No opinion	1,206 (42.8)	85 (43.6)	
Pediatrician's opinion on how baby should be fed in the first few weeks (*N*=2,621)			.45†
Only breastfed	1,097 (44.7)	69 (41.8)	
Only formula fed	30 (1.2)	4 (2.4)	
Both breastfed and formula fed	321 (13.1)	24 (14.6)	
No opinion	1,008 (41.0)	68 (41.2)	
Number of friends or relatives who breastfed their children (*N*=2,992)			.44
One or two	623 (22.3)	47 (24.2)	
Three to five	785 (28.1)	58 (29.9)	
More than five	1,048 (37.5)	60 (30.9)	

None have breastfed	87 (3.1)	7 (3.6)	
None have children or don't know	255 (9.1)	22 (11.3)	
Infant feeding attitudes and intentions among women who intend to breastfeed at all			
Somewhat or very comfortable breastfeeding in front of close women friends (*N*=2,613)	1,678 (68.6)	99 (60.0)	.02
Somewhat or very comfortable breastfeeding in front of men and women who you are close to (*N*=2,614*)*	991 (40.5)	60 (36.4)	.30
Somewhat or very comfortable breastfeeding in front of men and women who are not friends, *n* (%) (*N*=2,614)	485 (19.8)	33 (200	.95
Plan to continue breastfeeding after returning to work (*N*=2,494)			.43
Yes	1,243 (53.2)	76 (48.4)	
No	202 (8.6)	13 (8.3)	
Do not plan to work	892 (38.2)	68 (43.3)	
When plan to first give formula or other food besides breast milk (*N*=1,812)			.95
< 3 months	214 (12.5)	13 (12.9)	
3-4 months	486 (28.4)	30 (29.7)	
> 4 months	1,011 (59.1)	58 (57.4)	
When plan to completely stop breastfeeding in months, mean (SD) (*N*=2,404)	9.81 (5.33)	9.64 (4.77)	.75
Somewhat or very confident will breastfeed as long as planned (*N*=2,370)	1,554 (70.0)	93 (61.6)	.03

P values were obtained by X^2 tests for categorical variables and Wilcoxon rank sum test for continuous variables

Table 4.3. Logistic regression analyses of breastfeeding attitudes, beliefs, and perceptions during pregnancy associated with GDM Status (*N*=3,010)

	Odds Ratio (95% CI)		
	Unadjusted	Model 1 (Adjusted for maternal BMI only)	Model 2 (Adjusted for maternal BMI and demographics)
Formula is just as good as breast milk	1.43 (1.05-1.94)	1.33 (0.97-1.82)	1.32 (0.96-1.81)
Breastfeeding is the best way to feed newborn	0.60 (0.45-0.81)	0.59 (0.44-0.80)	0.62 (0.45-0.84)
Baby's father's opinion about how baby should be fed (compared to breastfed only)			
Only formula	2.00 (1.20-3.34)	1.88 (1.11-3.18)	1.74 (1.02-2.97)
Breast milk and formula	1.80 (1.24-2.61)	1.83 (1.25-2.66)	1.78 (1.21-2.61)
Not sure or no opinion	1.22 (0.84-1.78)	1.12 (0.77-1.64)	1.09 (0.74-1.62)
Baby's maternal grandmother's opinion about how baby should be fed (compared to breastfed only)			
Only formula	1.56 (0.90-2.70)	1.43 (0.82-2.49)	1.27 (0.72-2.23)
Breast milk and formula	1.59 (1.03-2.43)	1.51 (0.98-2.32)	1.40 (0.91-2.17)
Not sure or no opinion	1.60 (1.13-2.26)	1.45 (1.02-2.06)	1.35 (0.94-1.93)
Mother's doctor's opinion about how baby should be fed (compared to breastfed only)			
Only formula	3.25 (1.40-7.56)	2.87 (1.21-6.79)	2.82 (1.17-6.79)
Breast milk and formula	1.28 (0.82-2.01)	1.35 (0.86-2.13)	1.24 (0.78-1.96)
Not sure or no opinion	1.15 (0.83-1.58)	1.20 (0.87-1.65)	1.18 (0.85-1.64)
Mother's mother-in-law's opinion about how baby should be fed (compared to breastfed only) (*N*=2,807)			
Only formula	1.38 (0.69-2.77)	1.19 (0.59-2.40)	1.05 (0.52-2.14)
Breast milk and formula	1.25 (0.72-2.17)	1.23 (0.70-2.14)	1.16 (0.66-2.03)
Not sure or no opinion	1.66 (1.13-2.43)	1.52 (1.04-2.25)	1.43 (0.96-2.12)
Somewhat or very comfortable breastfeeding in front of women friends (*N*=2,613)	0.69 (0.50-0.95)	0.69 (0.50-0.96)	0.70 (0.50-0.98)
Somewhat or very confident will breastfeed as long as planned (*N*=2,377)	0.69 (0.49-0.96)	0.77 (0.54-1.09)	0.77 (0.54-1.10)

Demographic factors included maternal age, race (white vs. nonwhite), parity, education, income, WIC participation, employment status, and smoking status

Table 4.4. Comparison of respondents included and excluded from prenatal sample because of missing data, *N*=4,902

Characteristic	Excluded (*n*=1,892) *n* (%)	Included (*n*=3,010) *n* (%)	*P*
Primiparous (*N*=4,603)	628 (39.4)	858 (28.5)	<.001
Maternal pre-pregnancy BMI (kg/m^2) (*N*=4,711)			.08
<18.5	105 (6.2)	139 (4.6)	
18.5-<25	787 (46.3)	1,385 (46.0)	
25-<30	399 (23.5)	761 (25.3)	
≥ 30	410 (24.1)	725 (24.1)	
Mother's race/ethnicity (*N*=4,754)			<.001
White	1,340 (76.8)	2,523 (83.8)	
Black	146 (8.4)	154 (5.1)	
Hispanic	145 (8.3)	190 (6.3)	
Other	113 (6.5)	143 (4.8)	
Mother's education (*N*=4,278)			<.001
HS or less	382 (30.1)	674 (22.4)	
Some college	518 (40.9)	1,239 (41.2)	
College graduate or more	368 (29.0)	1,097 (36.5)	
Maternal age (*N*=4,890)			<.001
18-24	697 (37.1)	682 (22.7)	
25-29	581 (30.9)	1,000 (33.2)	
30-34	359 (19.1)	859 (28.5)	
≥ 35	243 (12.9)	469 (15.6)	
Income as % of poverty level (*N*=4,784)			<.001
<185	893 (50.3)	1,270 (42.2)	
185-349	574 (32.4)	1,067 (35.5)	
≥ 350	307 (17.3)	673 (22.4)	

Mother smoked during pregnancy, (*N*=4,752)	258 (14.8)	326 (10.8)	<.001
Marital status- not married, (*N*=4,306)	399 (30.8)	668 (22.2)	<.001
Mother or child enrolled in WIC (*N*=4,893)	832 (44.2)	909 (30.2)	<.001
Mother's employment status (*N*=3,981)			.35
Full-time	384 (39.6)	1,216 (40.4)	
Self-employed or part-time	168 (17.3)	567 (18.8)	
Not employed	419 (43.2)	1,227 (40.8)	
Weeks of maternity leave, mean (SD) (*N*=2,356)	9.13 (13.23)	8.95 (10.94)	.99

P values were obtained by Wilcoxon rank sum tests for continuous variables and X^2 tests for categorical variables

Table 4.5 Inverse-probability-weighted logistic regression analyses of breastfeeding attitudes, beliefs, and perceptions during pregnancy associated with GDM Status (*N*=3,010)

	Odds Ratio (95% CI)		
	Unadjusted	Model 1 (Adjusted for maternal BMI only)	Model 2 (Adjusted for maternal BMI and demographics)
Formula is just as good as breast milk	1.44 (1.06-1.97)	1.35 (0.99-1.84)	1.33 (0.96-1.84)
Breastfeeding is the best way to feed newborn	0.61 (0.45-0.82)	0.60 (0.44-0.81)	0.62 (0.46-0.85)
Baby's father's opinion about how baby should be fed (compared to breastfed only)			
Only formula	2.06 (1.23-3.45)	1.93 (1.14-3.26)	1.77 (1.04-3.03)
Breast milk and formula	1.80 (1.24-2.62)	1.83 (1.25-2.68)	1.77 (1.20-2.63)
Not sure or no opinion	1.26 (0.86-1.84)	1.16 (0.79-1.69)	1.12 (0.76-1.66)
Baby's maternal grandmother's opinion about how baby should be fed			
Only formula	1.59 (0.92-2.76)	1.46 (0.84-2.55)	1.29 (0.74-2.25)
Breast milk and formula	1.55 (1.01-2.38)	1.49 (0.96-2.30)	1.37 (0.88-2.14)
Not sure or no opinion	1.61 (1.13-2.28)	1.46 (1.03-2.08)	1.35 (0.93-1.94)
Mother's doctor's opinion about how baby should be fed			
Only formula	3.22 (1.38-7.52)	2.85 (1.22-6.65)	2.81 (1.17-6.74)
Breast milk and formula	1.25 (0.80-1.96)	1.32 (0.84-2.08)	1.21 (0.76-1.92)
Not sure or no opinion	1.13 (0.82-1.55)	1.18 (0.85-1.63)	1.16 (0.84-1.62)
Mother's mother-in-law's opinion about how baby should be fed (compared to breastfed only) (*N*=2,807)			
Only formula	1.37 (0.68-2.74)	1.17 (0.58-2.37)	1.04 (0.51-2.10)
Breast milk and formula	1.25 (0.72-2.17)	1.23 (0.70-2.15)	1.16 (0.65-2.05)
Not sure or no opinion	1.66 (1.13-2.43)	1.52 (1.03-2.24)	1.42 (0.95-2.10)
Somewhat or very comfortable breastfeeding in front of women friends (*N*=2,613)	0.69 (0.50-0.95)	0.69 (0.50-0.96)	0.70 (0.51-0.97)
Somewhat or very confident will breastfeed as long as planned (*N*=2,377)	0.70 (0.50-0.99)	0.79 (0.55-1.11)	0.79 (0.56-1.13)

Demographic factors included maternal age, race (white vs. nonwhite), parity, education, income, WIC participation, employment status, and smoking status

Table 4.6. Breastfeeding-related practices in the hospital and early problems with breastfeeding, by GDM status (*N*=1,733)

Item	NDM (*n*=1,626) *n (%)*	GDM (*n*=107) *n (%)*	*P*
Mother tried to breastfeed within one hour of birth (*N*=1,720)	965 (59.8)	58 (54.7)	.30
Mother got help breastfeeding at all	1,203 (74.2)	80 (74.8)	.87
Mother got help with breastfeeding within 1 hour of birth	380 (23.4)	16 (15.0)	.05
Baby fed sugar water in the hospital (*N*= 1,673)			.35
Yes	185 (11.8)	9 (8.8)	
No	1,243 (79.1)	80 (78.4)	
Don't know	143 (9.1)	13 (12.8)	
Baby was given a pacifier in the hospital (*N*=1,698)	902 (56.5)	52 (51.0)	.28
Baby stayed in mother's room in the hospital all the time, if not admitted to NICU (*N* =1,690)	932 (58.7)	45 (43.7)	<.01
Time until milk came in			<.01
1 day	148 (9.1)	10 (9.4)	
2 days	486 (29.9)	21 (19.6)	
3 days	607 (37.3)	44 (41.1)	
4 days	255 (15.7)	14 (13.1)	
More than 4 days	130 (8.0)	18 (16.8)	
Delayed onset of lactation (> 72 h postpartum)	385 (23.7)	32 (29.9)	.14
Reported problems with breastfeeding in the first 2 weeks			
Baby had trouble sucking	522 (32.1)	47 (43.9)	.01
Baby had trouble with choking	195 (12.0)	12 (11.2)	.81
Baby wouldn't wake up to nurse	379 (23.3)	25 (23.4)	.99
Baby was not interested in nursing	119 (7.3)	14 (13.1)	.03
Baby got distracted when nursing	75 (4.7)	3 (2.8)	.37
Baby didn't gain weight or lost too much weight	168 (10.3)	15 (14.0)	.23
Baby nursed too often	260 (16.0)	18 (16.8)	.82
Nipples were sore, cracked, or bleeding	95 (5.8)	10 (9.4)	.14
Mom didn't have enough milk for the baby	220 (13.5)	19 (17.8)	.22
It took too long for milk to come in	224 (13.8)	22 (20.5)	.05
Mom had trouble getting milk flow to start	843 (51.9)	59 (55.1)	.51

Breasts were overfull	625 (38.4)	33 (308)	.12
Mom had a yeast infection of the breast	34 (2.1)	3 (2.8)	.62†
Mom had a clogged milk duct	118 (7.3)	10 (9.4)	.42
Breasts were infected or abscessed	35 (2.2)	1 (0.9)	.72†
Breasts leaked too much	238 (14.6)	12 (11.2)	.33
Mom had some other problem	92 (5.7)	2 (1.9)	.09
Mom had no problem breastfeeding	192 (11.8)	9 (8.4)	.29

P values were obtained X^2 tests unless otherwise indicated

† Fisher's exact test

Table 4.7. Estimated unadjusted and adjusted odds ratios for postnatal outcomes for GDM vs. NDM (*N*=1,733)†

	Odds Ratio (95% CI)		
	Unadjusted	Model 1 (Adjusted for maternal BMI only)	Model 2 (Adjusted for maternal BMI, demographics, and perinatal factors)
Delayed onset of lactation (> 3 days postpartum)	1.38 (0.90-2.11)	1.25 (0.81-1.93)	1.26 (0.79-2.01)
Mother got help with breastfeeding within 1 hour of delivery	0.58 (0.33-0.99)	0.58 (0.33-1.00)	0.64 (0.36-1.15)
Baby always stayed in mother's room, among infants with no NICU stay (*N*=1,690)	0.55 (0.36-0.82)	0.53 (0.36-0.80)	0.55 (0.36-0.85)
Problems with breastfeeding in first 2 weeks			
Baby had trouble sucking	1.66 (1.12-2.46)	1.51 (1.01-2.25)	1.66 (1.08-2.54)
Baby was not interested in breastfeeding	1.91 (1.05-3.45)	1.77 (0.97-3.24)	2.06 (1.07-3.98)
It took too long for milk to come in	1.62 (0.99-2.64)	1.33 (0.81-2.20)	1.23 (0.72-2.08)
Other problem	0.32 (0.08-1.31)	0.27 (0.07-1.12)	0.23 (0.05-0.99)

†Postnatal outcomes associated with GDM in bivariate tests (*P* <.10)
Demographic factors included maternal age, race (white vs. nonwhite), education, income, parity, marital status, WIC participation, smoking status, and employment status
Perinatal factors included gestational weight gain, type of delivery, medication during labor; and infant birth weight, gestational age, birth weight category, and sex

Table 4.8. Comparison of mother-infant pairs included and excluded from postnatal sample because of missing data, *N*=3,033

Characteristic	Excluded (*n*=1,300) *n* (%)	Included (*n*=1,733) *n* (%)	*P*
Primiparous, (*N*=2,835)	367 (33.3)	461 (26.6)	<.001
Maternal pre-pregnancy BMI (kg/m^2) (*N*=2,879)			.20
<18.5	56 (4.9)	77 (4.4)	
18.5-<25	492 (42.9)	810 (46.7)	
25-<30	298 (26.0)	439 (25.3)	
≥ 30	300 (26.2)	407 (23.5)	
Mother's race/ethnicity (*N*=2,948)			.27
White	1,019 (83.9)	1,468 (84.7)	
Black	70 (5.8)	73 (4.2)	
Hispanic	72 (5.9)	111 (6.4)	
Other	54 (4.4)	81 (4.7)	
Mother's education (*N*=2,783)			<.001
HS or less	287 (27.3)	297 (17.1)	
Some college	420 (40.0)	700 (40.4)	
College graduate or more	343 (32.7)	736 (42.5)	
Maternal age (*N*=3,028)			<.001
18-24	387 (29.9)	316 (18.2)	
25-29	418 (32.3)	601 (34.7)	
30-34	311 (24.0)	523 (30.2)	
≥ 35	179 (13.8)	293 (16.9)	
Income as % of poverty level (*N*=2,915)			.001
<185	548 (46.4)	682 (39.4)	

185-349	396 (33.5)	646 (37.3)	
≥ 350	238 (20.1)	405 (23.4)	
Mother smoked during pregnancy (*N*=2,904)	176 (15.0)	118 (6.8)	<.001
Marital status- not married (*N*=2,801)	276 (25.8)	310 (17.9)	<.001
Mother or child enrolled in WIC (3,029)	591 (45.6)	557 (32.1)	<.001
Mother's employment status (*N*=2,578)			.04
Full-time	325 (38.5)	691 (39.9)	
Self-employed or part-time	144 (17.0)	351 (20.3)	
Not employed	376 (44.5)	691 (39.9)	
Weeks of maternity leave, mean (SD) (*N*=1,501)	9.94 (14.54)	8.89 (10.95)	.05
Gestational weight gain (*N*=2,800)			.32
Q1 <23 lbs	259 (24.3)	440 (25.4)	
Q2 23-<30 lbs	193 (18.1)	283 (16.3)	
Q3 30-<40 lbs	298 (27.9)	525 (30.3)	
Q4 ≥ 40 lbs	317 (29.7)	485 (28.0)	
Infant sex-female (*N*=3,030)	650 (50.1)	879 (50.7)	.74
Baby stayed in the NICU (*N*=3,033)	33 (2.5)	43 (2.5)	.92
Gestational age at birth (*N*=2,915)			.36
≥39 weeks	777 (65.7)	1,112 (64.2)	
37-38 weeks	344 (29.1)	543 (31.3)	
35-36 weeks	61 (5.2)	78 (4.5)	
Birth weight, kg, mean (SD) (*N*=2,915)	3.43 (0.49)	3.47 (0.46)	.02
Birth weight category (*N*=2,912)			.09
AGA	1,006 (85.3)	1,488 (85.9)	
SGA	52 (4.4)	51 (2.9)	
LGA	121 (10.3)	194 (11.2)	

P values were obtained by Wilcoxon rank sum tests continuous variables and X^2 tests for categorical variables

Table 4.9. Inverse-probability-weighted logistic regression analyses of postnatal outcomes for GDM vs. NDM (*N*=1,732)†

	Odds Ratio (95% CI)		
	Unadjusted	Model 1 (Adjusted for maternal BMI only)	Model 2 (Adjusted for maternal BMI, demographics, and perinatal factors)
Delayed onset of lactation (> 3 days postpartum)	1.37 (0.89-2.11)	1.24 (0.80-1.93)	1.24 (0.78-1.97)
Mother got help with breastfeeding within 1 hour of delivery	0.57 (0.33-0.99)	0.58 (0.33-1.00)	0.64 (0.36-1.14)
Baby always stayed in mother's room, among infants with no NICU stay (*N*=1,689)	0.54 (0.36-0.80)	0.53 (0.35-0.79)	0.55 (0.36-0.84)
Problems with breastfeeding in first 2 weeks			
Baby had trouble sucking	1.65 (1.11-2.45)	1.50 (1.00-2.25)	1.66 (1.08-2.56)
Baby was not interested in breastfeeding	1.82 (1.00-3.29)	1.70 (0.91-3.16)	1.97 (0.97-4.01)
It took too long for milk to come in	1.60 (0.98-2.61)	1.32 (0.79-2.19)	1.19 (0.70-2.04)
Other problem	0.30 (0.07-1.24)	0.26 (0.06-1.07)	0.22 (0.05-0.91)

†Postnatal outcomes associated with GDM in bivariate tests (*P* <.10)
Demographic factors included maternal age, race (white vs. nonwhite), education, income, parity, marital status, WIC participation, smoking status, and employment status
Perinatal factors included gestational weight gain, type of delivery, medication during labor; and infant birth weight, gestational age, birth weight category, and sex

CHAPTER 10

SUMMARY AND CONCLUSIONS

As increasing evidence points to the prenatal and postnatal environments as early determinants of long-term risk of obesity and chronic disease, it is essential to identify factors in these critical periods that can exacerbate or mitigate risk. We carried out three studies that contribute new knowledge that can be used to that end.

Consistent evidence suggests that infants who gain weight rapidly are at increased risk for obesity and potentially cardiovascular and metabolic diseases in later life. In our first study, we showed that infants who were not breastfed or were fed less than 100% breast milk in the first 6 months of life were 1.8-to-2.8 times more likely to gain weight rapidly between birth and 12 months of age. Breastfeeding intensity appeared to be a more important predictor of weight gain than exclusive breastfeeding duration, which was also inversely associated with likelihood of rapid weight gain, but not independently of breastfeeding intensity. This study is novel because it is one of few prospective studies that have examined the relationship between infant feeding and infant weight gain in a U.S. population and is the only U.S. study to use weight gain from birth to 12 months (as opposed to linear weight gain or a static weight measure) using the recommended WHO growth standards to define rapid weight gain.

Women with gestational diabetes are at particular risk of type 2 diabetes and their infants are at greater risk of later obesity and insulin resistance. Breastfeeding may reduce some of these risks for women with GDM and their infants, but little research has compared the infant feeding intentions and practices of women with GDM to nondiabetic women in the U.S. Our second study found that women with GDM were not less likely to

intend to breastfeed at all or exclusively, but they were nearly 40% less likely to initiate exclusive breastfeeding, even among women who indicated an intention to breastfeed exclusively. Among women who tried to breastfeed, those with GDM were 78% more likely to give their infants formula while in the hospital. These findings suggest that women with GDM are successful in meeting their own breastfeeding intentions and that early postpartum experiences may contribute to this phenomenon.

In our final study, we sought to identify factors that could influence the disparity in breastfeeding outcomes between women with GDM and nondiabetic women by comparing their breastfeeding-related knowledge, attitudes, and beliefs; and their early postpartum experiences. We identified several important differences in these factors between GDM and NDM women. During pregnancy, women with GDM were approximately 40% less likely to report breastfeeding as optimal feeding. They also had less social support for breastfeeding. GDM women were 74 and 78% more likely to indicate that the infant's father preferred formula feeding or mixed feeding, respectively, and nearly three times as likely to say that their obstetrician or other physician preferred formula use. Women with GDM were 30% less likely to say they felt comfortable breastfeeding in front of their women friends. Following delivery, infants born to women with GDM were almost half as likely to room-in with their mother. Women with GDM were 66% more likely to indicate that their infants had problems with sucking and about twice as likely to say their infants were not interested in breastfeeding. These findings highlight the need for additional support for women with GDM before and after delivery to improve their breastfeeding outcomes.

APPENDIX A

IFPS II PRENATAL QUESTIONNAIRE

synovate
Consumer Opinion Panel

Project FIRST

R867-97P
OMB No. 0910-0558
Expiration date: 12/31/2007

SECTION A: HEALTH AND HEALTH CARE

1. Are you currently pregnant and at least 18 years old?

   Yes ☐ No ☐ → (THANK YOU, PLEASE RETURN QUESTIONNAIRE IN THE ENCLOSED POSTAGE PAID ENVELOPE)

2. When is your baby due? (PLEASE WRITE IN MONTH AND DAY)

   MONTH: _____ DAY: _____

3. Who provides your prenatal care? (PLEASE "X" ALL THAT APPLY)

   - An obstetrician ☐
   - A family doctor, general practitioner, internist, or other physician ☐
   - A midwife or nurse midwife ☐
   - Another type of health care provider ☐
   - I am not getting prenatal care from a health professional ☐ → (GO TO QUESTION 5)

4. How many weeks pregnant were you when you went for your first prenatal visit?

   - 4 weeks or less ☐
   - 5 to 8 weeks ☐
   - 9 to 12 weeks ☐
   - 13 to 18 weeks ☐
   - 19 to 24 weeks ☐
   - 25 weeks or more ☐

5. Are you covered by any kind of health insurance or any kind of health care plan, such as insurance obtained through an employer or a government program like Medicaid?

   Yes ☐ No ☐

6. In the past month, were you enrolled in the WIC program or did you get WIC food or vouchers for yourself or for any of your children? (WIC is a program that gives food to pregnant and nursing women, babies, and young children.) (PLEASE "X" ALL THAT APPLY)

   Yes, I was enrolled or got WIC food for myself ☐ Yes, my child was enrolled or got WIC food ☐ No ☐

7. What was your weight just before you became pregnant? _____ POUNDS

8. How tall are you? _____ FEET _____ INCHES

9. What is your age? _____ YEARS

10. On the average, how many cigarettes do you smoke a day now? (*Write in 0 if you do not smoke).*

    _____ CIGARETTES PER DAY

11. How many people not including yourself smoke inside your home most days? (*Include family members, friends, and anyone else.)*

    0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 or more ☐

12. Have you had gestational diabetes with this pregnancy?

    Yes ☐ No ☐ Don't know ☐

13. As best you know, which of the following health conditions do you yourself or your baby's other relatives have? (PLEASE "X" ALL THAT APPLY)

	YOU, THE BABY'S MOTHER	THE BABY'S FATHER	THE BABY'S BROTHER OR SISTER	THE BABY'S GRANDPARENTS, AUNTS, OR UNCLES	NONE OF THESE RELATIVES
Juvenile onset diabetes (Type I)	☐	☐	☐	☐	☐
Adult onset diabetes (Type II)	☐	☐	☐	☐	☐
Asthma	☐	☐	☐	☐	☐
Eczema	☐	☐	☐	☐	☐
Food allergy	☐	☐	☐	☐	☐
Allergies to pollen, dust, animals, latex, or anything else	☐	☐	☐	☐	☐
Overweight or obesity	☐	☐	☐	☐	☐

14. Since you learned that you were pregnant, have you eaten more, less, or about the same of the following foods? If you did not eat the food before you learned that you are pregnant and you don't eat the food now, please mark "Did Not Eat Before or Now."

	EAT MORE	EAT LESS	EAT ABOUT THE SAME	DID NOT EAT BEFORE OR NOW
Milk or other dairy foods	☐	☐	☐	☐
Eggs	☐	☐	☐	☐
Canned tuna	☐	☐	☐	☐
Swordfish, shark, tile fish, or king mackerel	☐	☐	☐	☐
Any other type of fish	☐	☐	☐	☐
Shellfish	☐	☐	☐	☐
Luncheon meats	☐	☐	☐	☐
Nuts, peanuts, or peanut butter	☐	☐	☐	☐
Alcoholic drinks	☐	☐	☐	☐
Vitamin or mineral supplements	☐	☐	☐	☐
Any herbal or botanical supplement	☐	☐	☐	☐

IF YOU HAVE NOT EATEN LESS OF ANY FOOD LISTED IN QUESTION 14, GO TO QUESTION 16.

15. For each food that you are eating less of, please indicate the reason. **(PLEASE "X" ALL THAT APPLY)**

	UPSETS MY STOMACH OR MAKES ME FEEL SICK	MAY HARM MY BABY	TO PREVENT A FOOD ALLERGY IN MY BABY	OTHER REASON
Milk or other dairy foods	☐	☐	☐	☐
Eggs	☐	☐	☐	☐
Canned tuna	☐	☐	☐	☐
Swordfish, shark, tile fish, or king mackerel	☐	☐	☐	☐
Any other type of fish	☐	☐	☐	☐
Shellfish	☐	☐	☐	☐
Luncheon meats	☐	☐	☐	☐
Nuts, peanuts, or peanut butter	☐	☐	☐	☐
Alcoholic drinks	☐	☐	☐	☐
Vitamin or mineral supplements	☐	☐	☐	☐
Any herbal or botanical supplement	☐	☐	☐	☐

SECTION B: EMPLOYMENT

16. Did you work for pay at any time from the 3 months before you became pregnant up to the present time?

Yes ☐ No ☐ **➔(GO TO QUESTION 23)**

17. Using 1 to mean "None" and 5 to mean "Very much," how much satisfaction do you get from your paid work?

NONE (1)	(2)	(3)	(4)	VERY MUCH (5)
☐	☐	☐	☐	☐

18. About how much of your family's income comes from the money you earn from work? *(If you are no longer working, answer for the time you were working. If you have reduced your work hours because of your pregnancy, answer for the time before you reduced your hours.)*

Less than half ☐ About half ☐ More than half ☐

19. Do you work for pay now?

Yes, the same number of hours as before pregnancy ☐
Yes, but with reduced hours ☐
Yes, but on leave until after the baby's birth ☐ ➔ **(GO TO QUESTION 21)**
No ☐ ➔ **(GO TO QUESTION 23)**

20. How many hours per week do you usually work at this job now? *(If you work at two or more jobs, answer for the total number of hours you work.)*

1 to 9 hours per week ☐ 30 to 34 hours per week ☐
10 to 19 hours per week ☐ 35 to 40 hours per week ☐
20 to 29 hours per week ☐ More than 40 hours per week ☐

21. Thinking of work leave that you can use for maternity leave, how many weeks are you eligible for if you have no complications? *(Please write in the number of weeks of leave you are eligible for in each of the categories listed below. If you have no leave that you can use for maternity leave, write 0 in all.)*

_____ WEEKS OF FULLY PAID LEAVE _____ WEEKS OF PARTIALLY PAID LEAVE _____ WEEKS OF UNPAID LEAVE

22. In your opinion, how supportive of breastfeeding is your place of employment?

Not at all supportive ☐ Somewhat supportive ☐
Not too supportive ☐ Very supportive ☐

23. Do you plan to work for pay during your baby's first year?

Yes ☐ No ☐ **➔(GO TO SECTION C)**

24. How many weeks after the baby is born do you plan to return to work?

Fewer than 4 weeks ☐ 13 to 16 weeks ☐
4 to 6 weeks ☐ 17 to 20 weeks ☐
7 to 9 weeks ☐ 21 to 30 weeks ☐
10 to 12 weeks ☐ More than 30 weeks ☐

25. How many hours per week do you plan to work?

1 to 9 hours per week ☐ 30 to 34 hours per week ☐
10 to 19 hours per week ☐ 35 to 40 hours per week ☐
20 to 29 hours per week ☐ More than 40 hours per week ☐

26. How many hours per week would you prefer to work when you return to work?

1 to 9 hours per week ☐ 30 to 34 hours per week ☐
10 to 19 hours per week ☐ 35 to 40 hours per week ☐
20 to 29 hours per week ☐ More than 40 hours per week ☐
Would prefer not to work ☐

27. What will you do with your baby while you are working? **(PLEASE "X" ALL THAT APPLY)**

My baby will be cared for by a family member ☐ I will keep my baby with me while I work at home ☐
My baby will be cared for by someone not in my family ☐ I have not decided yet ☐
I will keep my baby with me while I work outside my home ☐

SECTION C: INFANT FEEDING

28. What method do you plan to use to feed your new baby in the first few weeks?

Breastfeed only (baby will not be given formula) ☐
Formula feed only ☐ ➔**(GO TO QUESTION 34)**
Both breast and formula feed ☐ ➔**(GO TO QUESTION 30)**
Don't know yet ☐ ➔**(GO TO QUESTION 33)**

29. How old do you think your baby will be when you first feed him or her formula or any other food besides breast milk?

Less than one month	☐	5 to 6 months	☐
1 to 2 months	☐	7 to 9 months	☐
3 to 4 months	☐	More than 9 months	☐

30. Do you plan to continue breastfeeding after you return to work?

Yes ☐ No ☐ Do not plan to work after the baby's birth ☐

31. How old do you think your baby will be when you completely stop breastfeeding?

_____ MONTHS

32. Using 1 to mean "Not at all Confident" and 5 to mean "Very Confident," how confident are you that you will be able to breastfeed until the baby is the age you marked in Question 31?

Not At All Confident (1)	(2)	(3)	(4)	Very Confident (5)
☐	☐	☐	☐	☐

33. Using 1 to mean "Very Uncomfortable" and 5 to mean "Very Comfortable," how comfortable would you be in the following situations?

	VERY UNCOMFORTABLE (1)	(2)	(3)	(4)	VERY COMFORTABLE (5)
Nursing your baby in the presence of close women friends	☐	☐	☐	☐	☐
Nursing your baby in the presence of men and women who are close friends	☐	☐	☐	☐	☐
Nursing your baby in the presence of men and women who are not close friends	☐	☐	☐	☐	☐

34. Which of the following statements is closest to your opinion? The best way to feed a baby is:

Breastfeeding	☐
A mix of both breast and formula feeding	☐
Formula feeding	☐
Breastfeeding and formula feeding are equally good ways to feed a baby	☐

35. How strongly do you agree or disagree with the following statements?

	STRONGLY DISAGREE	SOMEWHAT DISAGREE	NEITHER AGREE NOR DISAGREE	SOMEWHAT AGREE	STRONGLY AGREE
Infant formula is as good as breast milk	☐	☐	☐	☐	☐
If a baby is breastfed, he or she will be less likely to get ear infections	☐	☐	☐	☐	☐
If a baby is breastfed he or she will be less likely to get a respiratory illness	☐	☐	☐	☐	☐
If a baby is breastfed he or she will be less likely to get diarrhea	☐	☐	☐	☐	☐
Babies should be exclusively breastfed (fed only breast milk) for the first 6 months	☐	☐	☐	☐	☐
If a child was breastfed, he or she will be less likely to become obese	☐	☐	☐	☐	☐

36. How do the following people think your baby should be fed in the first few weeks? *(Mark "No one in this category" if there is no one in the category, such as if you don't yet have a pediatrician for the baby.)*

	ONLY BREASTFED	ONLY FORMULA FED	BOTH BREAST AND FORMULA FED	NO OPINION OR DON'T KNOW	NO ONE IN THIS CATEGORY
Baby's father	☐	☐	☐	☐	☐
Your mother	☐	☐	☐	☐	☐
Your mother-in-law	☐	☐	☐	☐	☐
Your obstetrician or other doctor	☐	☐	☐	☐	☐
Baby's pediatrician or other doctor	☐	☐	☐	☐	☐

37. How important are the following people's opinions in your decision about how to feed your baby?

	NOT AT ALL IMPORTANT	NOT VERY IMPORTANT	SOMEWHAT IMPORTANT	VERY IMPORTANT	NO ONE IN THIS CATEGORY
Baby's father	☐	☐	☐	☐	☐
Your mother	☐	☐	☐	☐	☐
Your mother-in-law	☐	☐	☐	☐	☐
Your obstetrician or other doctor	☐	☐	☐	☐	☐
Baby's pediatrician or other doctor	☐	☐	☐	☐	☐

38. About how many of your friends and relatives have breastfed their babies?

One or two	☐	None have breastfed	☐
Three to five	☐	None have children	☐ → (GO TO QUESTION 40)
More than five	☐	Don't know	☐

39. About how many of your friends and relatives have never breastfed their infants at all?

One or two	☐	None – all with babies have breastfed	☐
Three to five	☐	Don't know	☐
More than five	☐		

40. When you were babies, were you and the baby's father ever breastfed?

	Yes	No	Don't Know
You, the baby's mother	☐	☐	☐
Baby's father	☐	☐	☐

41. How many other babies have you had or adopted when younger than 12 months old? Do not include the baby you are expecting.

_____ OTHER BABIES HAD _____ BABIES ADOPTED

IF YOU HAVE NOT GIVEN BIRTH TO A BABY, GO TO SECTION D.

42. Have you ever given birth by cesarean?

Yes ☐ No ☐

43. Did you breastfeed, for any time at all, any of your other babies?

Yes ☐ No ☐ ➔(GO TO SECTION D)

44. How old was your baby when you stopped breastfeeding? *(If you have breastfed more than one baby, answer for the youngest one.)*

Less than one month	☐	7 to 9 months	☐
1 to 2 months	☐	10 to 12 months	☐
3 to 4 months	☐	More than 12 months	☐
5 to 6 months	☐		

SECTION D: OTHER INFORMATION

45. Have you heard about any problems in food related to:

	YES	NO
Listeria	☐	☐
Mercury	☐	☐
Dioxins or PCB's	☐	☐

IF YOU HAVE NOT HEARD OF ANY OF THESE PROBLEMS, GO TO QUESTION 47.

46. For each problem in Question 45 that you have heard of, do you remember what kind of food was related to the problem? **(PLEASE "X" ALL THAT APPLY)**

	SOME TYPES OF FISH	ALL TYPES OF FISH	SOME TYPES OF SHELLFISH	SOME TYPES OF MEAT OR CHICKEN	ALL TYPES OF MEAT OR CHICKEN	SOME TYPES OF CHEESES	SOME TYPES OF LUNCHEON MEATS	ALL TYPES OF LUNCHEON MEATS	DON'T KNOW
Listeria	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mercury	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dioxins or PCB's	☐	☐	☐	☐	☐	☐	☐	☐	☐

47. Have you have obtained information about your diet or about feeding babies from any of the following sources for this pregnancy or a previous one? For information about feeding babies, please think of breastfeeding, formula feeding, feeding solid foods, or any other infant feeding information.

	INFORMATION ABOUT MY DIET WHILE PREGNANT	INFORMATION ABOUT FEEDING BABIES	NO INFORMATION FROM THIS SOURCE
Doctor, nurse, or other health professional	☐	☐	☐
WIC food program	☐	☐	☐
Relative or friend	☐	☐	☐
Books or videos	☐	☐	☐
Newspaper or magazine	☐	☐	☐
Television or radio	☐	☐	☐
The web site, www.4woman.gov	☐	☐	☐
The web site, www.breastfeeding.com	☐	☐	☐
Other government web site	☐	☐	☐
Other non-government web site	☐	☐	☐

48. Have you recently seen, heard, or read anything about breastfeeding or about infant formula from the following places?

	BREASTFEEDING		INFANT FORMULA	
	YES	NO	YES	NO
TV	☐	☐	☐	☐
Magazine	☐	☐	☐	☐
Newspaper	☐	☐	☐	☐
Radio	☐	☐	☐	☐
On the internet or web	☐	☐	☐	☐
Billboards or outdoor posters	☐	☐	☐	☐

FOR QUESTION 49, PLEASE LOOK AT THE PICTURES ON THE AD INSERT INCLUDED WITH THIS QUESTIONNAIRE.

49. Have you recently seen the ads shown on the Ad Insert? Have you recently seen an ad…

	YES	NO	NOT SURE
On TV that shows a pregnant woman riding a mechanical bull? *See TV Ad 1*	☐	☐	☐
On TV that shows a pregnant woman drinking soda and eating greasy food? *See TV Ad 2*	☐	☐	☐
On TV that shows pregnant women in a log rolling competition? *See TV Ad 3*	☐	☐	☐
In a magazine or newspaper that shows two dandelions? *See Print Ad 1*	☐	☐	☐
In a magazine or newspaper that shows two otoscopes, the medical tool used to examine the ear? *See Print Ad 2*	☐	☐	☐
In a magazine or newspaper that shows two scoops of ice cream? *See Print Ad 3*	☐	☐	☐
In a magazine or newspaper or on a billboard or the internet that has only words giving a message about breastfeeding? *See Print Ad 4*	☐	☐	☐

50. Have you recently heard any ads on the radio that feature a man singing a song about breastfeeding? One ad is a song set to soul music and another ad is a song set to country western music. Have you recently heard either of these ads?

Yes, the soul music ad	☐	No, have not heard either	☐
Yes, the country western music ad	☐	Not sure	☐

51. Date you completed this form: MONTH ____ DAY _____ YEAR_____

52. As mentioned in the brochure, we need your current telephone number in order to ensure that you are involved at every step of Project FIRST.

My current telephone number is: _____ _____
Area code Telephone number

53. Are you the Synovate Consumer Opinion Panel Member?

Yes ☐ No ☐

THANK YOU.
PLEASE RETURN THIS QUESTIONNAIRE AND THE AD INSERT AS SOON AS POSSIBLE IN THE POSTAGE PAID ENVELOPE PROVIDED

APPENDIX B

IFPS II NEONATAL QUESTIONNAIRE

Job No. R868-01
OMB # 0910-0558
Expiration Date: 12/31/2007

Project FIRST

If you have older children, please think only about your youngest baby when you answer the questions.

SECTION A: YOUR NEW BABY'S BIRTH

1. Is your baby a boy or a girl? Boy..... ☐ Girl ..... ☐

2. What was your baby's length at birth? _____ INCHES

3. In the past month, were you or your baby enrolled in the WIC program or did you get WIC food or vouchers for yourself or for your baby? (WIC is a program that gives food to pregnant and nursing women, babies, and young children.) **(PLEASE "X" ALL THAT APPLY)**

   Yes, I was enrolled or got WIC food for myself..... ☐
   Yes, my baby was enrolled or got WIC formula or food..... ☐
   No..... ☐

4. When you were pregnant with this baby or with any other baby, did you attend any classes that discussed breastfeeding your baby? **(PLEASE "X" ALL THAT APPLY)**

   Yes, a class on breastfeeding..... ☐
   Yes, a child birth or baby care class that included breastfeeding..... ☐
   No..... ☐

5. Which type of health professional was your birth attendant?

   An obstetrician..... ☐
   A family doctor, general practitioner, internist, or other physician..... ☐
   A midwife or nurse midwife..... ☐
   Another type of health care provider..... ☐
   No health professional was present..... ☐

6. Other than the medical staff, who was with you during your labor? **(PLEASE "X" ALL THAT APPLY)**

   The baby's father..... ☐
   Relatives or friends..... ☐
   A professional labor support person, such as a doula..... ☐
   No one other than medical staff..... ☐

7. How was your baby delivered?

   Vaginally and not induced..... ☐
   Vaginally and induced..... ☐
   A planned cesarean..... ☐
   An unplanned or emergency cesarean..... ☐

8. Which of the following medications did you have during labor or delivery? **(PLEASE "X" ALL THAT APPLY)**

   General anesthesia (you were put to sleep)..... ☐
   A spinal or epidural..... ☐
   Demerol or Stadol..... ☐
   Nitrous oxide (gas breathed through a mask or mouthpiece while remaining conscious)..... ☐
   Pudendal block or other local blocks (injections into the vagina or cervix before the birth)..... ☐
   Other pain medication or don't know which pain medication..... ☐
   No pain medication..... ☐

9. How much weight did you gain during this pregnancy? _____ POUNDS

SECTION B: YOU AND YOUR BABY IN THE FIRST FEW WEEKS

10. How many nights were you in the hospital or birth center after your baby was born?

    None..... ☐ 1 night..... ☐ 2 nights..... ☐ 3 nights..... ☐ 4 to 7 nights..... ☐ More than 7 nights..... ☐

11. Was your baby given a pacifier by you, the medical staff, or anyone else while in the hospital or birth center?

    Yes..... ☐ No..... ☐ Don't know..... ☐

12. In your opinion, which statement best describes the attitude of the following people about feeding your baby? **(PLEASE "X" ONE BOX FOR EACH OF THE PEOPLE LISTED)**

	FAVORED BREASTFEEDING ONLY	FAVORED FORMULA FEEDING ONLY	FAVORED MIXED FORMULA AND BREASTFEEDING	HAD NO PREFERENCE FOR EITHER METHOD OF FEEDING	DON'T KNOW
Your doctor.....	☐	☐	☐	☐	☐
Baby's doctor.....	☐	☐	☐	☐	☐
Staff of hospital or birth center.....	☐	☐	☐	☐	☐

13. As best you know, what is the recommended number of months to exclusively breastfeed a baby, meaning the baby is only fed breast milk?

    _____ MONTHS

14. Did you receive a gift pack or diaper bag from the hospital or birth center? Include a gift pack from a child birth class if you took the class at the hospital or birth center.

    Yes..... ☐ No..... ☐ ➔ **(GO TO QUESTION 16)**

15. Were any of the following included in the gift pack? If you received more than one gift pack from the hospital or birth center, answer for all that you received. **(PLEASE "X" ALL THAT APPLY)**

    Infant formula..... ☐ Coupon for infant formula..... ☐ Breastfeeding supplies (nursing pads, nipple cream, etc.)..... ☐

16. Did you receive a gift pack from any place besides the hospital or birth center, for example, from your doctor or a child birth class taken somewhere other than the hospital?

    Yes..... ☐ No..... ☐

17. Have you received free samples of infant formula through the mail? Do not include coupons for formula.

    Yes..... ☐ No..... ☐

18. Did you ever breastfeed or try to breastfeed your baby, either in the hospital or birth center, or after you went home?

    Yes..... ☐ ➔ **(GO TO QUESTION 20)** No..... ☐

19. How important were each of the following reasons for your decision not to breastfeed your baby?

	NOT AT ALL IMPORTANT	NOT VERY IMPORTANT	SOMEWHAT IMPORTANT	VERY IMPORTANT
My baby was sick and could not breastfeed	☐	☐	☐	☐
I thought I would not have enough milk	☐	☐	☐	☐
A health professional said I should not breastfeed for medical reasons	☐	☐	☐	☐
I was sick or had to take medicine	☐	☐	☐	☐
I believe that formula is as good as breastfeeding or that formula is better	☐	☐	☐	☐
I thought that breastfeeding would be too inconvenient	☐	☐	☐	☐
I tried breastfeeding before and didn't like it or it didn't work out	☐	☐	☐	☐
I wanted to be able to leave the baby for several hours at a time	☐	☐	☐	☐
I wanted to go on a weight loss diet	☐	☐	☐	☐
I wanted to go back to my usual diet	☐	☐	☐	☐
I wanted to smoke again or smoke more than I should while breastfeeding	☐	☐	☐	☐
I had too many household duties	☐	☐	☐	☐
I planned to go back to work or school	☐	☐	☐	☐
I wanted or needed someone else to feed my baby	☐	☐	☐	☐
Someone else wanted to feed the baby	☐	☐	☐	☐
I wanted my body back to myself	☐	☐	☐	☐
The baby's father didn't want me to breastfeed	☐	☐	☐	☐
The baby's grandmother didn't want me to breastfeed	☐	☐	☐	☐
I wanted to use contraception that can't be used while breastfeeding	☐	☐	☐	☐

IF YOU NEVER BREASTFED AT ALL, GO TO SECTION C ON PAGE 3. ALL OTHERS PLEASE CONTINUE.

20. About how long after your delivery did you breastfeed or try to breastfeed your baby for the very first time?

Less than 30 min ☐ 3 to 6 hours ☐ 1 day ☐
30 to 60 min ☐ 7 to 12 hours ☐ 2 days ☐
1 to 2 hours ☐ 13 to 24 hours ☐ More than 2 days ☐

21. While you were in the hospital for delivery of this baby, did anyone help you with breastfeeding by showing you how or talking to you about breastfeeding?

Yes ☐ No ☐ ➔(GO TO QUESTION 25)

22. How many hours after the baby's birth did you *first* get help with breastfeeding?

Less than 30 min ☐ 3 to 6 hours ☐ 1 day ☐
30 to 60 min ☐ 7 to 12 hours ☐ 2 days ☐
1 to 2 hours ☐ 13 to 24 hours ☐ More than 2 days ☐

23. Who helped you with breastfeeding? **(PLEASE "X" ALL THAT APPLY)**

Doctor ☐ Lactation consultant ☐ Friend(s) ☐
Midwife ☐ Peer counselor ☐ Breastfeeding support group member ☐
Nurse ☐ Family member(s) ☐ Someone else ☐

24. Using 1 to mean "Not at all helpful" and 5 to mean "Very helpful," how helpful was the breastfeeding help you received from a doctor, midwife, nurse, or lactation consultant? **If you did not receive help from one of these, go to Question 25.**

NOT AT ALL HELPFUL (1)	(2)	(3)	(4)	VERY HELPFUL (5)
☐	☐	☐	☐	☐

25. While you were in the hospital or birth center, did your baby stay in your room day and night, except for doctor visits, bathing, or other treatments?

Yes, all the time ☐ ➔(GO TO QUESTION 28) Yes, some nights but not all ☐ No ☐

26. Was your baby brought to you for feeding during the night?

Yes ☐ No ☐

27. When your baby was not in your room, how did the staff decide when to feed the baby or to bring him or her to you for feeding? **(PLEASE "X" ALL THAT APPLY)**

Whenever he or she cried or seemed hungry ☐ Whenever you asked or went to get him or her ☐
On a schedule determined by the nurses or doctors ☐ Don't know ☐

28. During the first few days after your baby was born, did you feed him or her…

Whenever he or she cried or seemed hungry ☐ Sometimes on a schedule AND sometimes
On a schedule or routine ☐ when he or she cried or seemed hungry ☐

29. While you were in the hospital or birth center, was your baby fed water, formula, or sugar water at any time?

	YES	NO	DON'T KNOW
Water	☐	☐	☐
Formula	☐	☐	☐
Sugar water	☐	☐	☐

30. How long did it take for your milk to come in?

1 day or less ☐ 2 days ☐ 3 days ☐ 4 days ☐ More than 4 days ☐

31. Using 1 to mean "Disliked Very Much" and 5 to mean "Liked Very Much," how would you say you felt about breastfeeding during the first week you were breastfeeding?

DISLIKED VERY MUCH (1)	(2)	(3)	(4)	LIKED VERY MUCH (5)
☐	☐	☐	☐	☐

32. Were you given information about any breastfeeding support groups or services before you went home from the hospital or birth center?

Yes ☐ No ☐

33. When you left the hospital or birth center, how were you feeding your baby?

Breastfeeding only ☐ Formula feeding only ☐ Both breast and formula feeding ☐

34. Did you have any pain while breastfeeding at any time in the first 2 weeks?

Yes ☐ No ☐ ➔(GO TO QUESTION 36)

35. Using 0 to mean "No pain at all" and 10 to mean "The worst possible pain," how much pain, if any, were you in when you were breastfeeding during the following time periods? *(If you were not breastfeeding in some of the time periods, mark "NA" for Not Applicable.)*

	NO PAIN (0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	WORST POSSIBLE PAIN (10)	NA
1st day	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1st week	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2nd week	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

36. Did you have any of the following problems breastfeeding your baby during your first 2 weeks of breastfeeding? **(PLEASE "X" ALL THAT APPLY)**

My baby had trouble sucking or latching on	☐	I didn't have enough milk	☐
My baby choked	☐	My nipples were sore, cracked, or bleeding	☐
My baby wouldn't wake up to nurse regularly enough	☐	My breasts were overfull (engorged)	☐
My baby was not interested in nursing	☐	I had a yeast infection of the breast	☐
My baby got distracted	☐	I had a clogged milk duct	☐
My baby nursed too often	☐	My breasts were infected or abscessed	☐
It took too long for my milk to come in	☐	My breasts leaked too much	☐
I had trouble getting the milk flow to start	☐	I had some other problem	☐
My baby didn't gain enough weight or lost too much weight	☐	I had no problems	☐ → **(GO TO SECTION C ON THIS PAGE)**

37. Did you ask for help with these problems from a health professional (a doctor, midwife, or nurse), a lactation consultant, or a breastfeeding support group?

Yes ☐ No ☐

38. Did you get any help with these problems from a health professional, a lactation consultant, or a breastfeeding support group?

Yes ☐ No ☐ → **(GO TO SECTION C ON THIS PAGE)**

39. Did the help you received solve the problem(s) or make them better?

NO, NOT AT ALL (1)	(2)	(3)	(4)	YES, VERY MUCH (5)
☐	☐	☐	☐	☐

SECTION C: FEEDING YOUR BABY

40. In the past 7 days, how often was your baby fed each food listed below? Include feedings by everyone who feeds the baby and include snacks and night-time feedings.

If your baby was fed the food once a day or more, write the number of feedings per day in the first column. If your baby was fed the food less than once a day, write the number of feedings per week in the second column. **Fill in only one column for each item.** *If your baby was not fed the food at all during the past 7 days, write in 0 the second column.*

	FEEDINGS PER DAY	FEEDINGS PER WEEK
Breast milk	_____	_____
Formula	_____	_____
Water	_____	_____
Sugar water	_____	_____
Cow's milk or any other milk (rice, soy, goat, or other)	_____	_____
100% fruit or 100% vegetable juice	_____	_____
Sweet drinks (juice drinks, soft drinks, soda, sweet tea, Kool-Aid, etc.)	_____	_____
Baby cereal	_____	_____
Other **(PLEASE SPECIFY)** _____	_____	_____

41. How old was your baby when he or she was first fed formula?

1 day or less ☐ 7 to 13 days ☐ More than 20 days ☐
2 to 6 days ☐ 14 to 20 days ☐ Never fed formula ☐

42. What type of baby cereal was your baby fed in the past 7 days? **(PLEASE "X" ALL THAT APPLY)**

Baby was not fed baby cereal ☐ Dry cereal that you added a liquid to ☐ Cereal in a jar already mixed ☐

43. Was your baby given any herbal or botanical preparation or any kind of tea in the past 2 weeks? *(Do not count preparations applied to the baby's skin or anything the baby may have received through breastfeeding after you took an herbal or botanical preparation.)*

Yes ☐ No ☐ → **(GO TO QUESTION 45)**

44. Please list all the kinds of herbal or botanical preparations or teas your baby was given in the past 2 weeks.

_____

45. Which of the following was your baby given in vitamin or mineral drops at least 3 days a week during the past 2 weeks? If your baby was given drops that contained more than one of the items listed, please mark each of the separate items. **(PLEASE "X" ALL THAT APPLY)**

Fluoride ☐ Vitamin D ☐ None of these ☐
Iron ☐ Other vitamins ☐

IF YOUR BABY WAS FED FORMULA IN THE PAST 7 DAYS, PLEASE CONTINUE. ALL OTHERS GO TO QUESTION 55 ON PAGE 4.

46. In the past 7 days, about how many ounces of formula did your baby drink at each feeding?

1 to 2 ☐ 3 to 4 ☐ 5 to 6 ☐ 7 to 8 ☐ More than 8 ☐

47. Which formula was fed to your baby in the past 7 days? Infant formulas are listed alphabetically on the Formula List insert along with a group number. Please "X" the group number for each infant formula your baby was fed. **(PLEASE "X" ALL THAT APPLY)**

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
☐	☐	☐	☐	☐	☐

48. What type of infant formula was your baby fed? **(PLEASE "X" ALL THAT APPLY)**

Ready to feed ☐ Powder from can that makes more than one bottle ☐
Liquid concentrate ☐ Powder from single serving packs ☐

49. Which of the following describes the iron content of the formula you usually use?

With iron ☐ Low iron (additional iron may be necessary) ☐

50. How did you decide to use the formula you fed your baby in the past 7 days? **(PLEASE "X" ALL THAT APPLY)**

A doctor or other health professional recommended the formula	☐	I chose a formula labeled as useful for a problem my baby had	☐
I chose the same formula fed to my baby at the hospital	☐	I use the formula given by WIC	☐
I heard that the formula is better for my baby in some way	☐	I chose the same formula I fed an older child	☐
I chose the formula I received samples or coupons for	☐	Friends or relatives recommended the formula	☐
I saw an advertisement for the formula and wanted to try it	☐	I chose a formula based on low price	☐

51. Did you discuss your choice of formula with the baby's doctor?

Yes ☐ No ☐

52. During the past 2 weeks, how many times have you switched the formula you feed your baby?

None ☐ → **(GO TO INSTRUCTION ABOVE QUESTION 55)** 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 or more ☐

53. Did you switch formulas because your baby had a problem with the formula you were using?
Yes ☐ No ☐ → (GO TO INSTRUCTION ABOVE QUESTION 55)

54. What type of problem did your baby have with the formula(s)? (PLEASE "X" ALL THAT APPLY)

An allergic reaction or intolerance	☐	Too much gas	☐
Constipation	☐	Too much spit up	☐
Diarrhea	☐	Vomiting	☐
Too much mucus	☐	Other problem (Please specify_____)	☐

IF YOUR BABY WAS BREASTFED AT ALL IN THE PAST 7 DAYS, PLEASE CONTINUE. ALL OTHERS GO TO SECTION D ON THIS PAGE.

55. Since your baby was born, have you attended a breastfeeding class or breastfeeding support group?
Yes ☐ No ☐

56. Does your baby usually feed from both breasts at each feeding?
Yes ☐ No ☐ Baby is fed only pumped milk ☐ → (GO TO QUESTION 60)

57. Does your baby usually let go of the breast him or herself?
Yes, both breasts ☐ Yes, first breast only ☐ Yes, second breast only ☐ No ☐

58. About how long does an average breastfeeding last?

Less than 10 minutes ☐	20 to 29 minutes ☐	40 to 49 minutes ☐
10 to 19 minutes ☐	30 to 39 minutes ☐	50 or more minutes ☐

59. Using 1 to mean "Very Uncomfortable" and 5 to mean "Very Comfortable," how comfortable would you be in the following situations?

	VERY UNCOMFORTABLE (1)	(2)	(3)	(4)	VERY COMFORTABLE (5)
Nursing your baby in the presence of close women friends	☐	☐	☐	☐	☐
Nursing your baby in the presence of men and women who are close friends	☐	☐	☐	☐	☐
Nursing your baby in the presence of men and women who are not close friends	☐	☐	☐	☐	☐

60. In an average 24-hour period, what is the LONGEST time for you, the mother, between breastfeedings or expressing milk? Please count the time from the start of one breastfeeding or expressing session to the start of the next. Please think of time between feedings during both night and day to find the longest time. (WRITE IN THE NUMBER OF HOURS AND MINUTES)
_____ HOURS AND _____ MINUTES

61. How many times in the past 7 days was your baby fed expressed or pumped breast milk to drink? *(Write in 0 if your baby was not fed expressed or pumped milk to drink.)*
_____ TIMES

62. How old do you think your baby will be when you completely stop breastfeeding? _____ MONTHS

63. Using 1 to mean "Not at all Confident" and 5 to mean "Very Confident", how confident are you that you will be able to breastfeed until the baby is the age you marked in Question 62?

NOT AT ALL CONFIDENT (1)	(2)	(3)	(4)	VERY CONFIDENT (5)
☐	☐	☐	☐	☐

64. Using 1 to mean "Dislike Very Much" and 5 to mean "Like Very Much," how would you say you feel about breastfeeding now that your baby is several weeks old?

DISLIKE VERY MUCH (1)	(2)	(3)	(4)	LIKE VERY MUCH (5)
☐	☐	☐	☐	☐

65. Using 1 to mean "Never" and 5 to mean "Always," please choose the answer for each of the following statements that best describes how you feel about breastfeeding your new baby.

	NEVER (1)	(2)	(3)	(4)	ALWAYS (5)
I feel that I can find out what I need to know about breastfeeding my baby	☐	☐	☐	☐	☐
I feel that breastfeeding takes too much time	☐	☐	☐	☐	☐
I feel that my baby gets enough breast milk at each feeding	☐	☐	☐	☐	☐
I feel that I can breastfeed my baby whether it hurts or not	☐	☐	☐	☐	☐
I feel that my family supports my decision to breastfeed my baby	☐	☐	☐	☐	☐

SECTION D: OTHER INFORMATION

66. Has your baby used a pacifier in the past 7 days? Yes ☐ No ☐

67. Has your baby had jaundice at any time since he or she was born?
Yes ☐ No ☐ → (GO TO QUESTION 69)

68. How was the jaundice treated? (PLEASE "X" ALL THAT APPLY)

I fed formula in addition to breastfeeding for a while	☐	My baby was placed under a lamp (phototherapy)	☐
I stopped breastfeeding for a while	☐	My baby received an exchange transfusion	☐
I stopped breastfeeding and did not begin breastfeeding again	☐	My baby received some other treatment	☐
		No treatment was given	☐

69. Since the time your baby was discharged from the hospital after the birth, has he or she been hospitalized for any reason or has your baby been taken to a hospital for any outpatient procedure or surgery?
Yes ☐ No ☐ → (GO TO QUESTION 71)

70. How many nights was your baby in the hospital for the most recent problem since discharge after the birth? *(Write in 0 if your baby did not stay overnight.)*
_____ NIGHTS

71. Does your baby have any serious, long-term medical problems?
No ☐ Yes ☐ → (PLEASE EXPLAIN BRIEFLY) _____

72. Date you completed this form: Month _____ Day _____ Year _____

THANK YOU. PLEASE RETURN THIS QUESTIONNAIRE AS SOON AS POSSIBLE IN THE POSTAGE PAID ENVELOPE PROVIDED

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